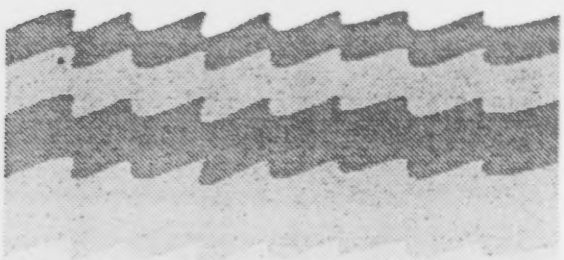
# COHO



## RESOURCE STATUS AND MANAGEMENT PLANNING PROCESS

# *INTERIM REPORT*

Fisheries and Oceans Pêches et Océans

Canada

STRAIT OF GEORGIA COHO SALMON
RESOURCE STATUS AND
MANAGEMENT PLANNING PROCESS

# *INTERIM REPORT*

*MARCH 1991*

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## EXECUTIVE SUMMARY

1. Declining wild coho salmon stocks in the Strait of Georgia, including the Fraser River, raise concerns about important commercial, sport and Indian food fisheries. Though supplemented increasingly in recent years by hatchery stocks, wild coho still provide the foundation for these fisheries, ensuring the genetic diversity essential to healthy fish populations. Properly managed, wild coho will continue to be a reliable, relatively inexpensive, and biologically sound resource.

2. Over-fishing and habitat loss are believed to have caused the decline in wild coho. The Department of Fisheries and Oceans (the Department) has, therefore, initiated a consultative planning process for rebuilding wild Strait of Georgia coho stocks. Two general objectives have been developed for the process:

   1) to preserve wild coho salmon stocks; and
   2) to maximize the benefits Canadians derive from this resource.

   These two objectives can most effectively be met by a plan which incorporates the protection of habitat, the enhancement of existing stocks, and the use of regulations to prevent overfishing.

3. The protection of habitat and the enhancement of existing stocks are critical long term investments. In the short term, coho salmon stocks can be effectively protected through regulatory action to reduce their exploitation rate. Analyses indicate that the average exploitation rate for these stocks should be reduced by approximately 10 percentage points to 65 to 70 percent. Once coho populations begin to rebuild as a result of reduced exploitation and increased habitat protection and enhancement work, regulatory measures will be reevaluated.

4. The Department is now midway through the consultative planning process, which began in late 1989. At the briefing session in May, 1990, advisory panel members selected from the native, commercial and sport sectors agreed on a six stage process:

   1) Status Report prepared by the Department
   2) Consultation
      - briefing for advisory panels
      - first workshops with panels
      - second workshops with panels
   3) Final report to the Pacific Regional Council (PARC)
   4) PARC recommendations to the Minister
   5) Minister's decision
   6) Implementation (expected in 1992)

As well, public open houses on the coho concern were held in several communities in the Strait of Georgia and the Fraser River watershed. Management options for rebuilding coho stocks identified during the consultation process will be forwarded in the final report to PARC.

5. This Interim Report summarizes the results of the first set of workshops, outlines the management options for rebuilding coho stocks identified to date, and provides preparation material for the second set of workshops. During the first set of workshops, the Department made presentations on coho stock status, enhancement, habitat, and harvest management.

6. Recent stock assessments indicate disturbing declines in spawning escapement and catch of many wild coho stocks on the south coast. The number of wild coho returning to spawn (spawning escapement) in Strait of Georgia and Fraser River streams declined by averages of 60 and 30 percent, respectively, from 1970 to 1988. Spawning also seems to be concentrated in fewer streams, leading to reduced genetic variability.

7. From 1976-1989, the catch of Strait of Georgia wild coho declined from 1-1.5 million to about 500,000. This decline translates into an average reduction in catch of Strait of Georgia wild coho of 66,000 fish per year since the late 1970's. However, a simultaneous increase in the proportion of Canadian hatchery fish in the catch has prevented the total coho catch from declining in many areas.

8. Enhancement is a tool to be used in rebuilding wild coho stocks, not a solution in itself. Enhancement objectives are: to conserve and rebuild natural stocks and to increase or maintain catch through enhancement where natural stocks are not negatively affected by such action. Guidelines for implementation of the objectives focus on sustaining weak stocks, maintaining genetic diversity, maintaining current catch levels in fisheries harvesting Strait of Georgia coho, and determining appropriate enhancement technology. It is expected that implementation of the new enhancement plans will begin in 1992, so their effects will not be felt until 1995 or later.

9. Habitat loss raises serious concerns for coho survival. Coho are particularly vulnerable to human settlement because they depend on low gradient, high quality freshwater streams for spawning and rearing. Human settlement tends to concentrate in just such low gradient areas, affecting the streams through water use, land development, storm water management and pollution, among other things. Suggested approaches to protecting habitat include increased public education and communication, strengthened federal-provincial cooperation in matters regarding water rights, and earlier participation in regional district land-use decision-making.

10. Management of Strait of Georgia and Fraser River coho is complicated by annual variations in stock distribution and migration patterns. As a result, these coho are harvested in many separate fisheries, and those that migrate outside the Strait move through a series of fisheries as they return to spawn. Management measures aimed at arresting the decline in Strait of Georgia coho, then, must take into account all the fisheries to which the coho are exposed.

11. It is important to note that the Department regulates individual fisheries in order to manage fish stocks. Therefore, the effects of regulatory actions must be evaluated for fish stocks as well as for fisheries. The terms exploitation rate and harvest rate have evolved to distinguish between stock impacts and fishery impacts. The exploitation rate is the proportion of the entire stock which is caught by all the fisheries combined. The harvest rate is the proportion of fish (which may come from a number of different stocks) caught in a given fishing area.

12. Native, commercial and sport fishery advisors reacted somewhat differently to the Department's presentation. Native advisors generally supported the South Coast Coho Initiative. They felt their main roles in the initiative were to ensure their harvest rate did not increase and to help to determine that harvest rate through cooperating in data collection and exchange with the Department. Commercial advisors feared being asked to take the brunt of any cutbacks. They stressed, therefore, that discussion of management measures for their own fisheries could only begin when evidence that the sport fishery would also be constrained by management measures was presented. Sport advisors felt the initiative should include Johnstone Strait and the east and west coasts of Vancouver Island. They questioned the accuracy of the data and the models upon which the management plan was based. All advisors agreed that habitat loss posed a major threat to coho production and should be addressed in a vigorous manner by governments and the public.

13. Queries by the advisors were so many and varied that a section of this report has been devoted to follow-up. The first part of this section contains responses to the questions that could not be answered at the workshops. The second describes the three kinds of fisheries management models used in determining and evaluating management options: Hook and Line, South Coast, and Linking. The third part reviews the effectiveness of recent management changes in the Johnstone Strait net fishery and concludes that reductions in fishing time from the early to mid 1980's have resulted in a decline in the coho harvest rate, although the extent of the decline cannot be quantified at this time. The last part discusses the potential inclusion of Johnstone Strait in the Initiative, agreeing that such an inclusion is desirable, but pointing out that a stock assessment for Johnstone Strait will not be

complete until 1992. It is suggested that discussions on the management needs of Johnstone Strait coho will then be held as a logical continuation of the current initiative.

14. The next section outlines possible fishery management measures and presents some options which use combinations of these measures to achieve exploitation rate reductions. Measures discussed for the tidal sport fishery include daily and seasonal bag limits, minimum size limits, a shorter fishing season, gear restrictions, spot closures, and a marked only fishery. For the commercial fishery, effort limitation, gear restrictions, area closures, and fixed, variable, and incidental catch ceilings are considered. Three main scenarios for distributing harvest rate reductions between the sport and commercial sectors are examined: 1) equal sport and commercial fishery reductions; 2) commercial fishery reduction larger than sport fishery reduction; and 3) sport fishery reduction larger than commercial fishery reduction. It is emphasized that these management measures and scenarios are provided as examples only, not recommendations.

15. The discussion of management options raises the question of how to decide among them, which leads into the next section of the report, evaluation. Evaluation consists of three stages: evaluation of management options; stock and fishery assessments; and evaluation of the target exploitation rate. Management options are evaluated through the use of fishery management models, which rank them according to the following indicators: effectiveness in reducing the exploitation rate; confidence in the underlying assumptions; and effect on the distribution of costs and benefits between user groups. As part of the annual monitoring process, stock status and fishery performance will be evaluated using a variety of indicators, most of which have been used in the current assessment. And, finally, the longer term evaluation of the target exploitation rate will be achieved in two ways. The productivity of specific coho salmon stocks will be studied in detail and spawner and recruit data will be analyzed to determine the optimal spawning level for maximizing catch.

16. This report will be discussed in detail at the second set of workshops. Preparation by the advisors for the second workshops should involve a review of this report. Are the best approaches being considered or are there better ones? The Department needs your input to develop a successful coho rebuilding plan.

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## 1.0 INTRODUCTION

Declining wild coho salmon stocks in the Strait of Georgia, including the Fraser River, raise concerns about future fisheries based on these stocks.

To address this issue, the Department of Fisheries and Oceans (the Department) has initiated a consultative planning process to develop a resource management plan for rebuilding coho salmon stocks. This Interim Report describes the coho concern, the planning process, results of the process to date, options for reducing the coho exploitation rate, evaluation methods, and preparations for the next step in the process (the second set of workshops).

## 1.1 BACKGROUND

### IMPORTANCE OF STRAIT OF GEORGIA WILD COHO

Coho salmon stocks in the Strait of Georgia (Figure 1), including the Fraser River, support important commercial, sport and Indian food fisheries. Though supplemented increasingly in recent years by hatchery stocks, wild coho still provide the foundation for these fisheries, ensuring the genetic diversity essential to healthy fish populations. Properly managed, wild coho will continue to be a reliable, relatively inexpensive, and biologically sound resource.

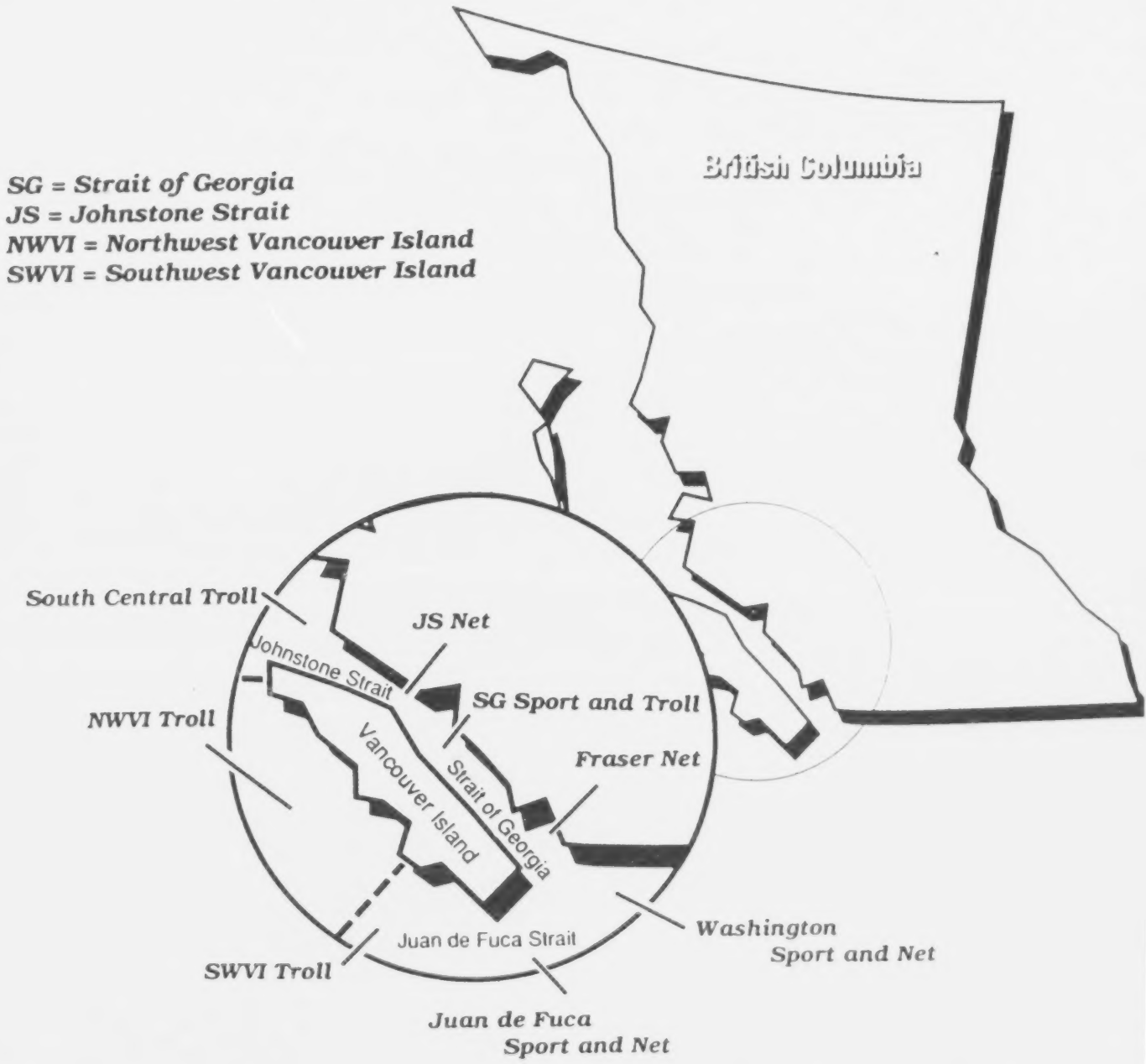
### THE CONCERN

Recent assessments by the Department's biologists indicate disturbing declines in spawning escapement and catch of many wild coho stocks on the south coast. The number of wild coho returning to spawn (escapement) in Strait of Georgia streams declined by an average of 60 percent from 1970 to 1988. In the lower Fraser and the Thompson Rivers, the decline in escapement has averaged about 30 percent. Spawning also seems to be concentrated in fewer streams, leading to reduced genetic variability.

From 1976-1989, the catch of Strait of Georgia wild coho declined from 1-1.5 million to about 500,000. This decline translates into an average reduction in catch of Strait of Georgia wild coho of 66,000 fish per year since the late 1970's. At the same time, the proportion of Canadian hatchery fish in the catch has increased from about 10 percent in the mid 1970's to about 40 percent in recent years. Consequently, in many areas the total catch has not been declining because the shortfall in wild coho has been made up through stock enhancement.

# FIGURE 1

## STRAIT OF GEORGIA AND FRASER RIVER COHO FISHERIES



THE REASONS

Over-fishing and habitat loss are believed to have caused the decline in wild coho. Though the effects of habitat loss are difficult to determine, the links between overfishing and declining coho populations can be traced directly. The rate at which Strait of Georgia coho are being caught -- the exploitation rate -- currently averages 10 percentage points higher than the 65-70 percent rate considered optimal for maximizing catch over the long term.

THE SOLUTION

The Department of Fisheries and Oceans has initiated a consultative planning process for rebuilding wild Strait of Georgia coho stocks. Two general objectives have been developed for the process:

1) to preserve wild coho salmon stocks; and
2) to maximize the benefits Canadians derive from this resource.

Preserving wild coho means maintaining coho populations above the level required to guarantee the long term survival of wild coho stocks. It also means supporting enough different coho stocks to ensure genetic variability. Maximizing benefits requires trade-offs between: current and future harvest needs; commercial, native, and sport catches; and harvests of other salmon stocks. These two objectives can most effectively be met by a long term plan which incorporates the protection of habitat, the enhancement of existing stocks, and the use of regulations to prevent overfishing.

THE CONSTRAINTS

A management plan for rebuilding coho stocks must take into account:

- stream and ocean habitat carrying capacities;
- the availability of government funding;
- social acceptance and the will for change; and
- existing policies of the Government of Canada.

**1.2 THE PROCESS**

Planning within the Department began in late 1989 with a briefing session held in May, 1990. This session was attended by advisory panels selected from each of the major sectors: native, commercial and sport. Participants discussed a draft Coho Status Report and agreed upon a six stage process culminating in implementation of the South Coast Coho Initiative.

1) Status Report prepared by the Department

2) Consultation
   - briefing for advisory panels
   - first workshops with panels
   - second workshops with panels
3) Final report to the Pacific Regional Council (PARC)
4) PARC recommendations to the Minister
5) Minister's decision
6) Implementation

As well, open houses held in several communities in the Strait of Georgia and the Fraser River watershed opened the South Coast Coho Initiative to public discussion. Management options for rebuilding coho stocks identified during the consultation process will be forwarded in the final report to PARC. Implementation of the management plan is expected to begin in 1992.

## 2.0 PROGRESS

The Department is now approximately midway through the planning process for the South Coast Coho Initiative. This section summarizes the progress made to date at the information session and at the first workshops held with each of the sectors: native, commercial and sport.

The information session, held on May 17-18, 1990, explained the Department's concern about the decline in wild coho stocks on the south coast and outlined the process to be followed in determining appropriate management measures. The draft document, "Coho: Resource Status and Management Planning Proposal", provided the basis for discussion. Presentations by Departmental personnel on coho stock status, enhancement, habitat, management, and the planning process were followed by questions from the participants, who represented the commercial, sport and native fishing sectors.

The first workshop was held with the Native Fishery Advisors on September 28, 1990, with the Commercial Advisors on October 4-5, 1990, and with the Sport Advisors on October 11-12, 1990. These workshops followed the same basic format as the information session, but offered considerably more detail.

To avoid redundancy, presentations made by the Department at the information session and at the first workshops have here been condensed into one section. Following that section is a synopsis of the advisors' responses.

## 2.1 THE DEPARTMENT'S PRESENTATION

### STOCK STATUS

The Department outlined the methods used to determine stock status as shown below.

1) Available escapement and catch data are analyzed to determine if any long term trends are detectable. Periodic fluctuations are normal, but a persistent declining trend usually indicates fishing at a level higher than stocks can sustain or a reduction in productivity.

2) The exploitation rate (proportion of the stock which is caught) for hatchery stocks is determined from coded wire tag recoveries in the catch and from spawning escapement. This rate is then compared with estimates of the exploitation rates required to maximize catch. These estimates are derived from life history models and stock and recruit models, which indicate that an average exploitation rate of 65 to 70 percent is required to maximize long term catch.

Although these pieces of information may vary in quality, they combine to form a compelling picture of declining wild coho catch and escapement caused by an over-harvest of Strait of Georgia wild coho. Coho exploitation rates currently average about 10 percentage points higher than the target rate of 65-70 percent. A continuation of such high fishery exploitation rates carries with it the likelihood of further declines and a significant reduction in the genetic diversity of wild stocks. More specific details on the different indicators of stock status are provided in the remainder of this section.

#### Spawning Escapement

The estimated number of wild coho spawning in index streams (consistently surveyed streams which are representative of a given area) is declining in all areas of the Strait of Georgia and the Fraser and Thompson Rivers. Escapements to central east coast of Vancouver Island (Statistical Area 14) index streams have declined by 60 percent since the 1970's. For both the Fraser and the Thompson rivers, the average escapement to the index streams during the 1980's was more than 30 percent below the 1970's average.

Escapement estimates for index streams in other areas of the Strait of Georgia: Campbell River/Comox (Statistical Area 13), Strait of Georgia mainland - north (Statistical Area 15), Strait of Georgia mainland-central (Statistical Area 16), and Nanaimo/Northern Gulf Islands (Statistical Area 17) have declined by 60 to 95 percent since the 1970's. Since the Cowichan River (Statistical Area 18), which contains the largest non-Fraser coho stock in the Strait of Georgia, does not have any index streams, assessment of this area is uncertain but is the subject of on-going research. Index streams in the Johnstone Strait area show declines similar to most Strait of Georgia areas.

## Catch Trends

The estimated total catch of Strait of Georgia wild coho salmon in all Canadian fisheries has declined sharply since the late 1970's.

The total catch of coho in the two major Strait of Georgia coho fisheries, the sport and commercial troll fisheries, has shown some fluctuations but has not declined significantly. However, when the known catch of Canadian hatchery fish and the estimated catch of U.S. origin stock (about 20 percent) is subtracted, the remainder, which is made up of Strait of Georgia wild coho stocks, has declined by 37 and 43 percent, respectively, for sport and troll fisheries (1985-89 average compared to 1976-80 average). The coho catch in the Strait of Georgia consists almost entirely of enhanced and wild Strait of Georgia and Fraser River stocks, and U.S. fish from Puget Sound. Tag recoveries show that coho from the outer coasts of Washington and Vancouver Island do not enter the Strait of Georgia in significant numbers.

The average catch of all coho in net fisheries in the Juan de Fuca Strait, Strait of Georgia, Johnstone Strait and the Fraser River declined by 26 percent between the 1976 to 1980 and 1985 to 1989 periods. A large part of this decline can be attributed to the curtailment in recent years of net fisheries, for which coho comprise a bycatch. This reduced catch has not led, however, to a noticeable increase in escapement or catches in other fishery, as might be expected if over-all abundance were high.

## Exploitation Rate

Exploitation rates for east coast of Vancouver Island and lower Fraser River hatchery coho stocks have averaged close to 80 percent over the most recent four year period for which data are available (1985-88). These exploitation rates are considered to be approximately ten percentage points higher than the optimum range of 65 to 70 percent for wild coho stocks. Within this optimum range, wild coho stocks should reproduce at a rate which would maximize catch over the long term.

Thompson River area stocks, as represented by the Eagle River hatchery, have experienced a lower average exploitation rate of 65 percent over the three year period for which tag returns are available (1986-88). This exploitation rate is within the optimum range for coastal stocks, but there is some concern among scientists that interior coho may be less productive than coastal fish and, therefore, may require a lower exploitation rate to maximize catch. Escapement data for the Tenderfoot hatchery (representing the mainland side of the Strait of Georgia) are not sufficiently reliable to provide accurate estimates of the exploitation rate for that area. West coast Vancouver Island stocks have been exploited at an average rate of 61 percent from 1985 to 1988.

Catch Distribution

Hatchery tag data indicate that the Strait of Georgia sport fishery catches the highest proportion of southeast and northeast Vancouver Island and Strait of Georgia mainland stocks and the second highest proportion of lower Fraser River and Thompson River stocks.

Troll fisheries, led by the Strait of Georgia and west coast of Vancouver Island (northwest and southwest) fisheries catch the highest proportion of the lower Fraser River and Thompson River catch and the second highest proportion of the catch of the remaining stocks. In addition to catching Strait of Georgia coho, the west coast of Vancouver Island troll fishery is the major harvester of coho stocks produced on the west coast of Vancouver Island.

Net fisheries can be important harvesters in some areas but generally take a small portion of the catch of all stocks.

ENHANCEMENT

Key enhancement objectives were presented and guidelines proposed. It was explained that enhancement is a tool to be used in rebuilding wild coho, not a solution in itself. The guidelines were meant to provide a framework for discussion and planning of enhancement. They take into account the facts that all stocks are not equally productive and that enhancing every stock is neither biologically, genetically, economically nor logistically viable or desirable.

Conceptual, rather than stock-specific, comments on the role of enhancement in rebuilding Strait of Georgia coho were requested from participants. It was explained that stock-specific input would be appropriate in about a year when enhancement action is approved. In the meantime, suggestions made by advisors would be analyzed in the context of the proposed regulatory measures and incorporated in the guidelines where appropriate. Implementation of the new enhancement plans would probably begin in 1992, so their impacts would not be felt until 1995 or later.

Objectives

1. To conserve and rebuild natural stocks by:

   - increasing productivity to meet spawning targets;
   - increasing the number of hatchery fish where management measures protect natural stocks; and
   - increasing or restoring fisheries habitat.

2. To increase or maintain catch where natural stocks are not negatively affected by such action.

Guidelines

1) Stocks that are unable to naturally sustain themselves at the 65-70 percent exploitation rate may be sustained through enhancement.

2) To maintain genetic diversity within a stock, escapement of enhanced fish will not exceed 50 percent of the total natural spawning population target for that stock.

3) The maximum production increases considered will be those required to maintain current catch levels in fisheries harvesting Strait of Georgia coho, keeping in mind that:

   - incremental production will be implemented as quickly as possible;
   - it is expected that catch will exceed current catch as natural stocks rebuild, at which point enhancement levels may be adjusted to suit the Strait of Georgia's carrying capacity; and
   - maximum production increases would require funding well in excess of that currently available.

4) The Salmonid Enhancement Program (SEP) will develop the most appropriate enhancement strategy for increasing Strait of Georgia coho numbers, given the following considerations:

   - a range of technological approaches will be considered;
   - habitat restoration and improvement will be emphasized;
   - opportunities for colonization of unutilized habitat will be documented and pursued; and
   - hatchery smolt releases will be increased as necessary to achieve coho production goals.

## HABITAT

Coho salmon spend their first year or two rearing in freshwater habitats. Once they emerge as fry, they take up residence in small tributaries, backwater channels, ponds and marshes, and along lake margins before migrating to the ocean as smolts in the spring. Those that survive the ocean return to spawn in the clean gravels of small streams. This dependency upon freshwater rearing and spawning habitat makes coho particularly vulnerable to impacts. These impacts occur as a result of water withdrawal for domestic, industrial and irrigation purposes, waste effluent discharges and agricultural runoff, poor land development, insensitive logging, land clearing and poor farming practices. In addition, the effects of construction and maintenance of roads, transmission and pipelines, and other activities combine to threaten the freshwater habitats essential to coho production and survival. All these impacts can be expected to intensify as the population continues to increase in B.C. The most threatened habitat is in the streams within the lower Fraser Valley and around

the Strait of Georgia.

There are many examples where significant coho habitats have already been lost in these areas. Following massive flooding in 1948, a complex system of dykes, floodgates and pumping stations was constructed in the lower Fraser Valley to protect agricultural, industrial and residential areas from floods. This resulted in major land reclamations and coho habitat losses. Many of the coho populations that survived subsequently faced restricted access to natal streams in the fall when the floodgates were often closed during low water. Also, induced smolt mortalities occur annually each spring when the smolts are forced to pass through the pumping stations during the Fraser River high runoff periods. Once the dyke protection systems were built, the government agency that built them was dissolved and the municipalities inherited them, but not the resources necessary to correct the fish-related problems.

Another concern is the way water is allocated in the Province of B.C. Unfortunately, water for fish is not currently defined to be a primary use in the hierarchy of water uses in the Provincial *Water Act*. Through the process of water licensing, many stream flows have become fully subscribed, and as a result, coho suffer from seriously low summer rearing conditions and depleted fall spawning flows. Another related problem stems from human settlement and the growth of our cities, towns and suburbs. As more land is occupied by people, streams are used as storm water ditches and runoff channels and become incapable of sustaining any significant numbers of fish. This has been the fate of many streams in the lower Mainland and the towns surrounding the Strait of Georgia. The prospects of correcting this problem are poor unless major improvements in community planning, environmental awareness and stream stewardship are achieved.

The incremental impacts of habitat disruptions are not well known and it is only possible to quantify habitat losses in the most obvious cases where hydro-electric and water supply developments have removed habitat from coho production above dams and reduced productivity downstream. The amount of productive habitat already lost cannot be assessed due to the lack of biophysical information. A significant amount of habitat inventory and mapping work is required to develop a habitat data base. More coho research will yield a better understanding of the relationship between habitat and coho utilization. However, this work is very expensive and time consuming. Nevertheless, effective protection and restoration of stream habitats exposed to impacts are dependent on this information.

The Government of Canada's strong mandate to protect fish habitat is embodied in the *Fisheries Act*. In 1986, the Department released the *Policy for the Management of Fish Habitat*. The goals of this policy are fish habitat protection and conservation, restoration, and development, and the overall objective is a net gain of productive capacity of fish habitat. The guiding principle is no net loss of the productive capacity of fish habitat. To achieve no net loss, guidelines to protect fish habitat have been developed. For example, guidelines are available for coastal fish/forestry and for urban, pipeline, bridge and culvert construction. The bulk of the Department's habitat management workload continues to be

the review of referrals of projects and plans for work in or near stream or foreshore habitats. The referral process was developed so that problems could be resolved before fish habitat was detrimentally affected. A referral is reviewed by Department staff and possible modifications are discussed with the proponent and criteria for the protection of fish habitat are provided. The final design is approved or rejected according to the risk to fish habitat. Field staff inspect the project during the construction phase.

Although referrals represent a large part of the habitat workload, the Department has a habitat restoration program. Current habitat restoration projects range from ground-water fed sidechannels and sidechannel restorations, development of water storage and salmon flow management strategies, and spawning gravel placement, to the clean-up of streams in industrial and suburban areas and estuaries. This program is relatively new and emphasizes small stream projects. Support for habitat restoration is growing among communities and public and corporate interest groups and there is scope for much greater participation, investment, and sponsorship.

Pressures on our streams arising from economic expansion and development are compounded by the fact that there are many overlapping, and in some cases, competing jurisdictions and policies. These complex interactions and conflicts occur because these jurisdictions are derived from single purpose legislation. To provide better coordination, governments have created project review processes to ensure that all environmental concerns are investigated. The Federal Environmental Assessment and Review Process (EARP) and Provincial Review Process, coupled with a major change in public attitudes to the environment, have positively influenced industry and local governments. Streams are now seen to be year round salmon and trout nurseries that must be protected. As a result, developers and some industries are becoming more receptive to habitat protection measures. The Department's challenge is to protect what habitat is left, and restore what can be restored.

Several new initiatives could be considered to ensure that fish habitat is protected and restored. For example, public education and media communications must highlight habitat and it value. Communities could review their processes for zoning stream corridors and wetlands. The Department must improve planning by integrating the operations of staff who are responsible for the protection and production of the stocks with those who are responsible for fish stock harvest. Governments must put a new emphasis on integrated resource planning and management by effecting cooperation between federal and provincial ministries and their local (community) counterparts. The provincial Ministry of the Environment has begun the process of establishing integrated resource management. The Department and the provincial government expect some positive administration changes in this area. Increased consultation and communication between the Department, the public and user groups will also create better understanding of the problems and solutions. The methods necessary to preserve water habitats and lands surrounding particularly endangered areas may need to be explored. The concept of securing land for conservation purposes is

not new; both in Canada and elsewhere private sector organizations such as *Ducks Unlimited* and *Wildlife Habitat Canada* have leased or purchased critical sites to protect threatened habitats.

The following initiatives could help resolve some of the habitat problems.

**1) Education and Communication**

Residents of B.C need to be more informed about the importance and fragility of the high quality freshwater habitat vital to coho survival. Education can foster an understanding of, and respect for, fish and their habitats, the importance of fish in B.C.'s economy, and the interactions between other economic activities and fishery resource use.

An existing project is the "*Salmonids in the Classroom*" program sponsored by the Department's Salmonid Enhancement Program. It has been expanded to include aspects of fish habitat and the life histories of salmonids. This program could be further expanded to a secondary level of studies focusing on land-water and environmental issues (eg. "*Salmonids in the Community*"). Broadly based salmon education/documentary programs designed to reach adults and professionals should also be considered.

The goal of this initiative is to increase the individual citizen's ability to make choices that positively influence the future health and prosperity of our fishery resources.

**2) Federal/Provincial Cooperation**

Protection of fish habitat is complicated by overlapping federal and provincial jurisdictions. For example, the Department is concerned with maintaining water quality in salmon habitat, but the Provincial Waste Management Branch issues the permits for effluent discharge into provincial waters. A new initiative has recently occurred in the form of the Provincial Integrated Resource Management Branch. This new branch is mandated to facilitate the resolution of resource use conflicts. The Department hopes that this expansion to a multilateral process coordinated by the new branch will lead to faster, more equitable resource conflict resolutions. In some cases, local issues can be resolved more easily if an integrated approach is pursued early. For instance, in spite of the present limitations to the *Water Act*, the Regional Water Management Branch on Vancouver Island has coordinated water management planning in aid of wild chinook management for several rivers of high Departmental priority (eg. Cowichan, Nanaimo). Such cooperative solutions to jurisdictional problems are productive and are being actively encouraged and pursued where possible by the Department. Major agreements such as the coastal fish/forestry guidelines illustrate how productive such an approach can be.

An initial agreement to share in the collection and management of fish habitat information has been established between the Minister of the Department of Fisheries and Oceans and the provincial Minister of the Environment. This agreement has formed the foundation for systematically organizing and cataloguing information on the improved management of fish habitats. The new Stream Summary Catalogues are an example of a cooperative project to provide stream synopsis information throughout B.C. This initiative could be refocused and redefined to help support other coho initiatives.

3) **New Partnerships, People in Communities and Local Governments**

Various factors, such as water extraction, land zoning, pollution and loss of riparian habitat, result in degraded stream corridors for fish. Without a long term plan, the natural environmental assets of a community are ultimately lost. Currently, the Department is not involved in the planning of zoning and development strategies until after zoning has been approved and land has been purchased. Consequently, the Department becomes involved only after much of the investment for land purchase is completed, the development boundaries have been delineated along streams and wetlands, and the general engineering design is underway. This lack of early involvement often precludes a productive discussion of changes which incorporate fish habitat requirements and forces the Department into enforcement actions.

The Department should examine the feasibility of becoming involved much earlier in the community planning process. Information about coho habitats (and other salmon species) could be mapped and made available to community planning departments so that specific measures describing fish habitat protection requirements could be incorporated in their development zoning process under the authority of the *Municipal Act*. A **Developers and Planners Guide to Stream Values and Stewardship** could be an effective new tool in communicating our goals and describing what is required to protect coho. This guide would provide advice and assist developers so that they could be more creative in their project designs, and instruct them on how to save time and money by contacting government agencies much earlier in the development process. This initiative will take time and resources to implement and is heavily dependent on changing attitudes and fostering the willingness of local governments and developers to work together on a project with the goal of protecting fish habitats.

## HARVEST MANAGEMENT

Management of the catch or harvest of Strait of Georgia and Fraser River coho is complicated by variations in distribution and migration patterns from stock to stock and year to year. Tag recoveries show that most of the catch of these stocks occurs in the Strait of Georgia fishery. Many of these coho, however, migrate to the west coast of Vancouver Island and the south central coast to rear and are harvested in outside areas (Table 1). Those that escape the outside fisheries return as mature fish through Johnstone and Juan de Fuca Straits. Management measures aimed at arresting the decline in Strait of Georgia wild coho, then, must take these major fisheries into account.

### Major Fisheries

While the impact of a particular fishery on a particular Strait of Georgia or Fraser River coho stock will depend on stock distribution and fishing intensity, the same group of fisheries consistently harvests the majority of these fish (Table 1). Commercial troll fisheries off the west coast and in the Strait of Georgia, commercial net fisheries in Juan de Fuca, Johnstone Strait, Strait of Georgia and the Fraser River, and the sport fishery in the Strait of Georgia harvest from 83 to 95 percent of Strait of Georgia and Fraser River stocks on average. Indian food fisheries in the Fraser, Squamish and Capilano rivers also harvest these stocks, but coded wire tags are not collected from Indian food fish, so the impact of these fisheries on specific stocks cannot be assessed. The estimates of stock composition provided in this section are taken from a preliminary analysis conducted by the Pacific Salmon Commission (Figure 2) and are currently under review.

The west coast Vancouver Island troll fishery harvests 1.8 million coho annually (1985 to 1989 average). Less than 20 percent of these fish originate in the Strait of Georgia and Fraser River, while over 60 percent are of U.S. origin. In 1951, the west coast Vancouver Island troll fishery was open from May 21 to Nov 30. By 1984, the fishing period was reduced to July 1 to Sept 21, and each troller was restricted to 6 lines and gurdies. A 1.8 million coho catch ceiling was implemented in 1985 as part of the Pacific Salmon Treaty to limit the interception of U.S. origin coho.

The south central troll fishery harvests an average of 180,000 coho annually, of which less than half originate in the Strait of Georgia and the Fraser River. In most cases, the south central troll fishery is opened at the same time as the west coast Vancouver Island troll.

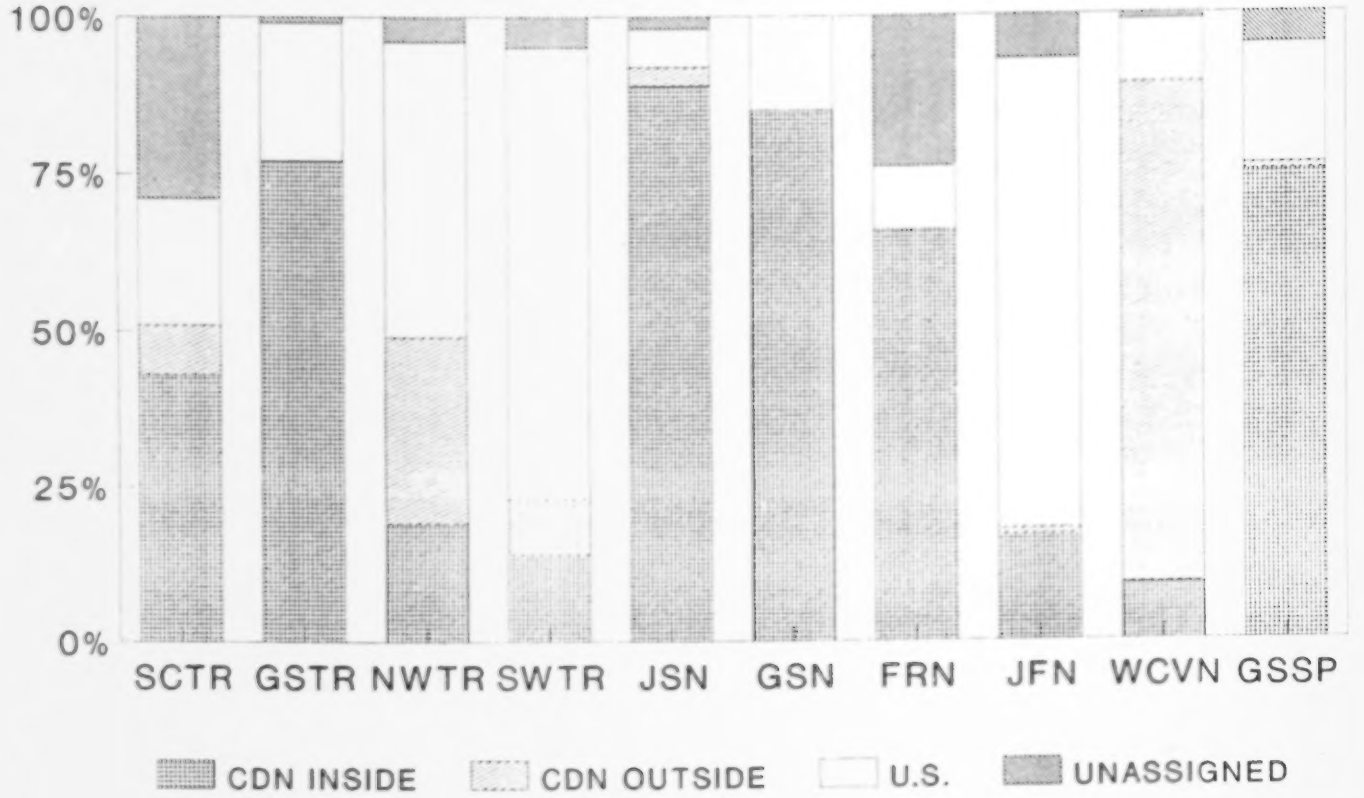
The Strait of Georgia troll fishery harvests an average of 200,000 coho annually (1985-1989); approximately three quarters of these fish originate in Strait of Georgia and Fraser River, while the remainder originate in U.S streams. Prior to 1956, the Strait of Georgia troll fishery was opened from June 1 to November 30; by 1965, this season was reduced to July 1 to Sept 30. Each vessel was restricted to four lines and gurdies in 1979, but this was changed to six lines and gurdies in 1981 (consistent with the outside troll restrictions) when

## TABLE 1
## DISTRIBUTION OF CATCH FOR B.C. SOUTH COAST COHO STOCKS AS INDICATED BY HATCHERY TAGGING DATA

| | Southeast Vancouver Island | Northeast Vancouver Island | Strait of Georgia Mainland | Lower Fraser River | Thompson River | West Coast of Vancouver Is. |
|---|---|---|---|---|---|---|
| **Strait of Georgia Sport** | **46.6%** | **47.7%** | **58.7%** | **39.2%** | **22.8%** | **0.3%** |
| Strait of Georgia Troll | 11.9% | 8.3% | 7.0% | 19.0% | 4.1% | 0.0% |
| Southwest Vancouver Island Troll | 9.0% | 3.1% | 9.6% | 15.9% | 31.4% | 42.1% |
| Northwest Vancouver Island Troll | 5.8% | 6.4% | 4.1% | 5.6% | 9.1% | 42.5% |
| Central B.C. Troll | 5.4% | 13.0% | 2.1% | 2.4% | 4.0% | 5.4% |
| Northern B.C. Troll | 0.0% | 0.4% | 0.4% | 0.2% | 0.3% | 1.3% |
| **Total B.C. Troll** | **32.1%** | **31.1%** | **23.3%** | **43.0%** | **48.8%** | **91.3%** |
| Strait of Georgia Net | 6.0% | 0.3% | 0.6% | 50.0% | 0.2% | 0.0% |
| Juan de Fuca Net | 2.4% | 0.8% | 2.8% | 220.0% | 2.0% | 1.0% |
| Johnstone Strait Net | 7.1% | 15.8% | 2.5% | 160.0% | 2.4% | 0.6% |
| Fraser Net | 0.0% | 0.0% | 0.6% | 180.0% | 5.6% | 0.0% |
| **Total B.C. Net** | **15.5%** | **16.8%** | **6.5%** | **6.0%** | **11.2%** | **1.6%** |
| **Total U.S.** | **3.9%** | **1.4%** | **9.2%** | **8.8%** | **16.9%** | **4.9%** |
| Other | 1.8% | 0.3% | 2.3% | 3.0% | 3.0% | 1.9% |
| Grand Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Exploitation Rate | 78.6% | 78.6% | Not Available | 77.1% | 65.0% | 61.5% |

Note: The percentages are the averages for the years 1985 to 1988 for the following hatcheries: Big Qualicum River, Southeast Vancouver Island; Quinsam River, Northeast Vancouver Island; Robertson Creek, West Coast of Vancouver Island; Tenderfoot Creek, Strait of Georgia Mainland; Chilliwack River, Chehalis River, and Inch Creek for the Lower Fraser River, and Eagle River for the Thompson River (1986-88 only).

# FIGURE 2
# ESTIMATED COHO STOCK COMPOSITION IN SOUTHERN B.C. FISHERIES
(PRELIMINARY ANALYSIS)




SCTR • SOUTH CENTRAL TROLL
GSTR • STRAIT OF GEORGIA TROLL
NWTR • NORTHWEST VAN. IS. TROLL
SWTR • SOUTHWEST VAN. IS. TROLL
JSN • JOHNSTONE STRAIT NET
GSN • STRAIT OF GEORGIA NET
FRN • FRASER RIVER NET
JFN • JUAN DE FUCA NET
WCVN • WEST COAST VAN. IS. NET
GSSP • STRAIT OF GEORGIA SPORT

two area licensing was implemented. In 1989, the troll fishery was restricted to a ceiling of 31,000 chinook, but no ceiling was placed on coho.

Juan de Fuca net fisheries harvesting surplus sockeye and pink salmon are under Pacific Salmon Commission control until pink and sockeye fishing ends in September. Incidental coho catches have averaged 195,000 coho in recent years (1985 to 1989). Less than 20 percent of these coho originate in Strait of Georgia and Fraser River, with the remainder made up mostly of U.S. origin coho.

Johnstone Strait net fisheries harvest surplus sockeye pink and chum and catch an average of 107,000 coho annually (1985 to 1989). Most of these fish originate in the Strait of Georgia and Fraser River. An evaluation of recent management actions in the Johnstone Strait net fishery is provided in Section 3.0.

Strait of Georgia and Fraser River net fisheries have harvested averages of 14,000 and 20,000 coho, respectively, from 1985 to 1989. The coho catch in both fisheries is taken incidentally during chum, pink and sockeye fisheries, but some directed fishing for surplus hatchery coho has occurred in the Strait of Georgia. Most of the coho taken are produced in the Strait of Georgia and the Fraser River, while a small fraction originate in U.S. waters. The Fraser River fisheries are under Pacific Salmon Commission control until October. Mesh size, net size and hang-ratio are restricted for gill nets, while net size and bunt mesh size and the use of power skiffs are restricted for seine boats (except in Juan de Fuca Strait, where power skiffs are permitted).

The Strait of Georgia sport fishery catches an average of 700,000 coho per year (1985 to 1989). Approximately three quarters of these coho originate in Strait of Georgia and Fraser River while the remainder originate in the U.S. It is likely that the sport catch in the Juan de Fuca Strait contains a much higher percentage of coho of U.S. origin. In 1964, sport anglers were restricted to four salmon per day. In the early 1980's many terminal areas were closed to conserve wild stocks (Toba, Bute, Loughbrough). Howe Sound was closed from July 15 to Sept 15, and the Fraser River mouth was closed. In the mid 1980's, 31 separate area closures were implemented to conserve chinook, and the Howe Sound closure was extended from June 1 to September 30. In the mid 1980's the chinook daily bag limit was set at two, the size limit was increased, and an annual bag limit was set. Recreational fishing for coho has, in recent years, been permitted off the mouth of the Fraser River for part of the season.

Indian food fisheries in the Strait of Georgia occur primarily in the Fraser, Capilano, and Squamish Rivers, where harvests in the 1980's have averaged, respectively, 28,000, 11,000 and 3,000 coho. Indian food fishing is regulated to meet both the food and ceremonial needs of native people. Fishing techniques are adapted to local areas and include angling and the use of dip nets, set gill nets, drifted gill nets, gaffs, spears, and weirs. Fishing is regulated through licences which generally set gear and fishing time restrictions.

Exploitation and Harvest Rates

Exploitation rate and harvest rate are two related concepts which are critical to an understanding of how fisheries managers evaluate the impacts of management actions on both fisheries and stocks.

> The **exploitation rate** is the proportion of the stock which is caught by all fisheries combined. It is a measure of the total fishing impact on a stock.
>
> The **harvest rate** is the proportion of the fish which are caught in a given fishing area. Harvest rate is a measure of the impact of a fishery on the fish (which may come from a number of different stocks).

An example may help to illustrate this point. Figure 3a shows a simple conceptual model in which a stock is vulnerable to three sequential fisheries. The stock originates in fishing area A and each fishery harvests 50 percent of the fish available to it. Fishery C fishes on the fish escaping from fishery B, which fishes on the fish escaping from fishery A. Fishery A catches 500 fish, fishery B catches 50 percent of the 500 fish which escape from fishery A (250), and fishery C catches 50 percent of the 250 fish which escape from fishery B (125). Of 1000 fish, 875 are caught and 125 spawn, so the exploitation rate is 875/1000 or 87.5 percent, even though the harvest rate in each fishery was only 50 percent. As this example demonstrates, the exploitation rate is a function of the distribution of the stock and the harvest rates in all the fisheries to which the stock is vulnerable.

Figure 3b shows the same model with all the harvest rates reduced by 10 percentage points to 40 percent. The catch in fishery A drops 20 percent, from 500 fish to 400 (40 percent of 1000 fish). The catch in fishery B drops to 240 fish, a decline of only 4 percent. Even though the harvest rate in fishery C is reduced by 10 percentage points, fishery C is now catching 40 percent of the larger group of fish which escapes fishery B, so this catch actually goes up by 15 percent. Overall, the exploitation rate is reduced to 78.4 percent, a drop of just over 9 percentage points. Spawning escapement increases by 73 percent.

It is important to note that:

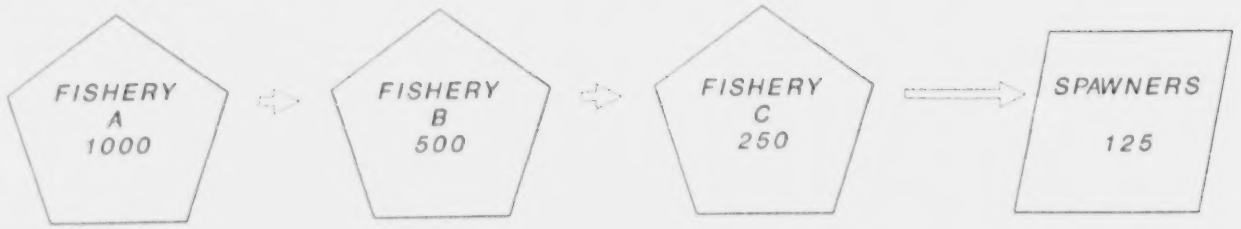
1) when harvest rate reductions are equal, the impacts on the fisheries are not, because some fisheries are harvesting the fish that escape from other fisheries; and

2) in the first example, no fishery is harvesting more than 50 percent of the fish available to it, yet almost 90 percent of the total stock is exploited because the fisheries are sequential.

FIGURE 3

## CONCEPTUAL MODEL OF EFFECT OF HARVEST RATE CHANGE ON EXPLOITATION RATE

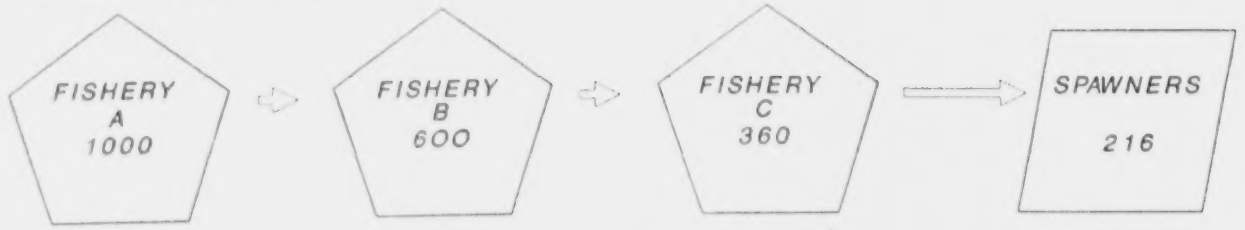
3A: 50% HARVEST RATE




CATCH: 500 250 125

TOTAL CATCH: 875 EXPLOITATION RATE: 87.5%

3B: 40% HARVEST RATE




CATCH: 400 240 144

TOTAL CATCH: 784 EXPLOITATION RATE: 78.4%

The Department's goal is to reduce the exploitation rate for Strait of Georgia and Fraser River coho stocks from about 78 percent to about 68 percent (which is a 10 percentage point or 12.8 per cent reduction in exploitation rate). That means that the harvest rate allowed each of the many fisheries which intercept Strait of Georgia coho must be reduced enough to ensure that the overall exploitation rate for Strait of Georgia coho falls within the 65-70 percent target range.

Management Measures

The Department outlined a number of management options and explained how the effectiveness of the option chosen would be evaluated over time. Sections 4.0 and 5.0 provide this information in greater depth than time permitted at the workshop.

## 2.2 THE ADVISORS' REACTIONS

INFORMATION SESSION

The advisors raised a number of concerns, including predation of newly released enhanced fish, potential differences between the behaviour of hatchery fish and that of wild fish, use of surplus aquaculture fish to augment hatchery production, and ways of increasing the marine survival rate. They questioned the effectiveness of the National Habitat Policy's guiding principle of "no net loss." Advisors further questioned the reliability of the escapement and coded wire tag data used to develop exploitation rates. They also raised questions about the integration of the Coho Initiative with other projects and activities, such as the Fraser River Sustainable Development Plan to increase sockeye production, the Department's coho management plans for the north coast, and the Canada/USA Pacific Salmon Treaty. Freshwater sport fisheries and directed net fisheries in Juan de Fuca Strait, the US, and off Qualicum were identified by the advisors as possible contributors to the decline in wild coho.

WORKSHOP 1

Native Advisors

The native advisors expressed general support for the South Coast Coho Initiative, although they did identify a number of concerns. They asked about the amount and range of enhancement, the source of stock for enhancement, the definition of an enhanced fish versus a wild fish, the basis for determining ideal stock numbers, and the effects of interactions between wild and enhanced coho.

Habitat, the native advisors felt, needed a comprehensive public education program, strong support for rehabilitation and restoration, and protection from poor land use planning through improved communication with developers. In particular, they suggested that the consultation process requires re-examination with respect to involvement of the regional

district, improved land and water planning, and a strengthened provincial role. An emergency response habitat protection lab and hot line were proposed and adequate funding was identified as critical to successful habitat protection.

After emphasizing their goal of native fishery co-management, native advisors agreed that the proposal to reduce the coho exploitation rate by 10 percentage points was generally acceptable. They did, however, express concern about how harvest rates would be assessed and applied. Questions were also asked about the Department's surplus fish policy, the relative roles of pollution and predation in the decline of wild coho, and the impacts of U.S. and driftnet fisheries. Overall, the role of the native food fishery in the South Coast Coho Initiative was determined to be one of ensuring that existing harvest rates did not increase. Further clarification of existing harvest rate levels was, however, found to be necessary. This clarification would be achieved by improved data exchange, which would be dependent on the case-by-case development of logistical arrangements for data collection and exchange with the Department.

Commercial Advisors

The commercial advisors were concerned that they would be compelled to bear the brunt of any cutbacks as they felt they had in the past. They made it clear that they would not discuss management measures for their own fisheries until it became clear that the sport fishery would also be constrained by management measures. With this proviso in mind, they did, however, approve of some aspects of the plan. The enhancement guidelines, for instance, were generally felt to be very practical. Commercial advisors were more concerned about the peripheral issue of fish farms and the potential swamping effect of inadvertent releases than about the enhancement guidelines themselves.

Commercial advisors also approved of habitat's general approach of improved education, review of new development proposals, and active pursuit of rehabilitation opportunities. Questions revolved around the effectiveness of regulations, the complexity of habitat management, the cost of colonization, and the method of determining coho survival rates.

The commercial advisors would not commit to any specific management measures. Questions were asked about the harvest and exploitation rate knowledge base, the actual reductions in catch contemplated, and why discussion revolved around harvest and exploitation rates rather than numbers of fish caught. It was agreed that harvest rate reduction options need to be further explored. They felt that reduction of approach and outside fisheries appears costly and offers few benefits. Inside fishery reduction, on the other hand, made more sense but still involved costs. Questions were also asked about how the management plan would accommodate increased fishing effort in the sport fishery.

Compensation for the inside troll fishery and the need for cuts in the sport fishery were discussed. Commercial advisors asked how they would benefit from participating in the South Coast Coho Initiative. They found the Department's proposed means of evaluating the effectiveness of the 10 percentage point exploitation rate reduction acceptable but needed assurance that the reduction would have the desired effect in rebuilding coho stocks. They stressed that the reductions would mean a direct loss of income for commercial fishermen.

While making no commitments, commercial advisors did discuss some options for reducing wild coho catch. Gear modifications and avoidance of areas with a known high incidence of coho were seen as possibilities. Marked only fisheries could, they suggested, be instituted for the sport sector and species trade-offs were suggested for the Indian food fishery, particularly since such trade-offs are already occurring for chinook on Vancouver Island.

Sport Advisors

Sport advisors felt that the South Coast Coho Initiative was not sufficiently comprehensive and they questioned the accuracy of the data and models upon which the management plan was based. Specifically, sport advisors said the initiative should include Johnstone Strait and the east and west coasts of Vancouver Island. They also asked about the time frame for coho fishery cutbacks, the viability of hatchery fish as indicator stocks, and the difference between the harvest and exploitation rates.

Sport advisors felt the enhancement guidelines sounded reasonable but would be unlikely to receive adequate funding, leaving commercial and sport fisheries to bear the brunt of cutbacks. They emphasized the need for an holistic approach to management of coho stocks, wherein enhancement and habitat programs would be expanded in focus and geographical scope before exploitation rates were reduced. They also questioned the definition of a hatchery fish, the 50 percent enhancement guideline and the guideline regarding the sustaining of stocks that can't support the 65-70 percent exploitation rate.

The sport advisors expressed great concern over habitat loss and proposed that the Sport Fishing Advisory Board work together with the federal and provincial governments to preserve habitat. Discussion revolved around the need for a proper habitat inventory, habitat effects on coho survival, federal and provincial roles in habitat protection, and enforcement of habitat protection regulations. Questions were later asked about the effects of human populations on water temperature and quality. The sport advisors stressed the needs for a proactive approach to habitat protection and for incentives for compliance and suggested establishing habitat monitors in companies.

Sport advisors expressed a general dissatisfaction with management measures taken in the past and a distrust of fishery models as viable predictors of the effects of management actions. They asked whether the Department had made any assumptions regarding species targeting in the sport fishery and whether the models allowed for increased sport fishing

effort due to population growth. They requested an indication of the number of coho to be foregone and suggested that the U.S. would benefit from Canadian cutbacks in the coho fishery.

Considerable concern was expressed over the harvesting practices of the commercial fishery and proposed that stock conservation would be more effective if the sport fishery were allocated the resource. An initial suggestion that trollers be restricted from harvesting coho was later modified to a species interchange between user groups. Commercial fishermen would even, it was put forward, make more money by interchanging coho for pink, sockeye or chum.

Sport advisors suggested that court cases currently being held regarding the Indian food fishery may impact fishery resources.

Management options suggested by the sport advisors included the possibility of species interchange between user groups. They also proposed that the intensive commercial net fishery could be timed to avoid the high tourist season in July and August, especially since the July commercial fishery is, they thought, usually poor anyway.

Finally, the sport advisors underlined the importance of assessing the effectiveness of the evaluation of exploitation rate reductions and suggested that key stream indicators are needed for north and south Vancouver Island and Johnstone Strait.

## 3.0 FOLLOW-UP

This section responds to the many requests for further information made by fishery advisors during the first series of workshops. The first part contains responses to the questions that could not be answered at the workshops themselves, the second reports on the discussions of a special committee set up to review the models used in determining and evaluating management options, the third reviews the effectiveness of recent management changes in the Johnstone Strait net fishery, and the last part addresses the possibility of including Johnstone Strait in the geographical scope of the South Coast Coho Initiative.

## 3.1 QUESTIONS AND ANSWERS

### STOCK STATUS

Q1. How good is your information?

A1. The quality of the data used in the Department's analysis is highly variable, not unlike data used in assessing and managing most salmon stocks in British Columbia. Catches for commercial and most sport fisheries are believed to be estimated with a high degree of accuracy, although concern does exist about the accuracy of estimates of the

number of small chinook caught in nets. Catch estimates for commercial fisheries derived from sales slips are probably more accurate than those for sport fisheries derived from creel surveys (which provide monthly catch and angler effort information), which are in turn more accurate than Indian food fish estimates. Exploitation rate and hatchery contribution estimates are derived from coded wire tag recoveries from fisheries and from spawning populations. These data have been used extensively in the assessment and management of chinook and coho salmon in both Canada and the United States and the quality of these data is the subject of on-going technical evaluation in both countries. Spawner enumeration data is probably the most uncertain of all of the data used because of the lack of consistent survey methodology and the inherent difficulty in estimating the numbers of spawning coho in streams with poor viewing conditions. However, these data are believed to be indicative of the trend in spawner levels over time.

## ENHANCEMENT

Q1. What are some examples of the Department's successful habitat enhancement projects and how much has been spent on them?

A1. Described below are projects carried out by the Resource Restoration Unit (RRU) of the Salmonid Enhancement Program (SEP) which provide good examples of successful habitat enhancement.

1) Groundwater-fed Side Channels

The groundwater-fed side channel is the most common type of project undertaken by RRU, mainly because of its demonstrated productivity and low operational and maintenance requirements. Forty such channels have been constructed during the past 12 years. Although side channels were originally intended to extend and improve spawning habitat for chum salmon, the technique has also recently been used for sockeye. In addition, the channels have been found to provide excellent spawning and rearing habitat for coho. Upper Paradise Valley Channel, located on the Cheakamus River near Squamish (construction cost $22,000) and Worth Creek Channel in the Fraser Valley (construction cost $8,000) are typical of this type of project.

2) River Intake Side Channels

RRU staff have experimented with a number of intake designs aimed at maintenance-free operation. An example of a river intake channel project is Lang Creek Channel on the Sunshine Coast near Powell River. Construction cost was $41,000.

3) Estuary Development

Only one project of this type has been carried out so far: the Ladner Lagoon project located on the Fraser River estuary. It involved excavating a number of interconnecting channels in a tidal marsh to provide access for juvenile salmonids to the rich foraging potential of the marsh. Construction cost was $40,000.

4) Off-channel Ponds for Juvenile Salmonid Rearing and Overwintering

Coal Creek Ponds, located to one side of a small stream on Vancouver Island near Courtenay, consist of a series of ponds connected by riffle sections. The water supply to the ponds is diverted from the stream via a simple intake structure. Construction cost was $56,000.

5) Cattle Fences Along Stream Banks

Salmon streams in many parts of the interior of the province have been damaged by cattle which trample the banks, causing siltation of stream beds and destroying stream bank vegetation. A pilot fencing project, aimed at restoring the integrity of stream banks, was carried out at Duteau Creek near Vernon, B.C. in 1989. This project cost $40,000.

6) Stream Diversions

Typically, high gradient streams draining the steep lateral slopes of river valleys produce few salmonids, since they provide very little suitable spawning or rearing habitat. Some such streams lend themselves to diversion, whereby part or all of the base flow is rerouted along a more level course, while most of the excess flood flow follows the original steep course. The diversion of Sequilla Creek, a Kingcome River tributary, at a cost of $12,000, is an example of this type of project.

7) Screening to Prevent Juveniles from Entering Irrigation Ditches

An innovative design has been developed for a screening device which prevents juveniles from entering irrigation ditches and other hazardous waterways. Called the "Finnigan Screen," this self-cleaning structure has been installed at several locations, including a ranch on the Chilcotin River in 1990 at a cost of $8,000.

8) Adult Migration Barriers

Coates Creek on the west coast of the Queen Charlotte Islands is a stream without salmon due to an impassable falls at tidewater. In 1987, a work crew (which included

labour funded through a government job creation program) carried out a combination of rock blasting and concrete pool and weir construction to build a fishway. The cost totalled $10,200.

Annual Expenditures on Habitat Improvement Projects

Annual expenditures on habitat improvement and restoration projects by the Resource Restoration Unit, including reconnaissance and feasibility studies and travel, but excluding wages and administration costs, for the fiscal years 1988/89 to 1990/91 were:

| | | |
|---|---|---|
| 1988/89 | - | $350,000 |
| 1989/90 | - | $400,000 |
| 1990/91 | - | $500,000 |

Q2. Is the 50 percent rule the same as for chinook?

A2. The 50 percent rule proposed for coho enhancement is identical to that implemented for lower Strait of Georgia chinook.

Q3. Does the enhancement program focus more on commercially caught species than on species, such as coho and chinook, traditionally caught by sport fishermen?

A3. It is difficult to calculate the exact expenditures by SEP on each species because many projects enhance more than one species of salmonid. Recent analysis indicates, however, that 70 percent of the SEP operating budget for fiscal year 1989/90 was spent on enhancement of chinook, coho, steelhead and cutthroat, the balance being spent on chum, sockeye and pink salmon. The comparative estimate for 1980/81 is 58 percent expenditure on traditional sport species, although some of these species are caught in the commercial fishery.

These estimates seem to contradict the known numerical predominance of enhanced commercial species over enhanced sport species, but they reflect the fact that species caught by sport fishermen are usually more costly to produce (brood stock capture is often difficult and most juveniles are reared for months or years before release) than commercial species.

Q4. Why don't you gear up more SEP facilities to address this problem?

A4. Increased SEP production will not provide a solution to diminishing wild stocks unless such increases are complemented by new regulatory measures. Since the Department will not know the nature of such measures until the planning process is completed, increased enhancement before completion of the process would be premature.

Q5. What role does public education play in this process?

A5. Public education will help people to understand that they can play an important role in rebuilding and maintaining coho populations. Through this coho initiative we hope to educate the interested public through the media, open houses, and workshops. Additional future activities, such as expanding the Salmonid education program in the classroom to reflect more on habitat and its importance to coho, may also be initiated.

HABITAT

Q1. Is there information available to demonstrate that some streams are under-seeded?

A1. Yes. Although comprehensive documentation is not yet available for all streams on the south coast, it is known that many streams, such as the small ones in the Baynes Sound area, have very low spawner or rearing fry populations.

Q2. Are coastal logging guidelines effective in protecting fish habitat?

A2. Yes, it is the Department's view that they are effective when followed. The coastal logging guidelines take into account the major lessons learned from the Carnation Creek study:

1) the importance of large organic debris for stability, habitat, and protection;

2) the importance of sidechannel habitats for coho production (about 24 percent of total coho production occurs in sidechannels);

3) the importance of stream-side vegetation and stable banks in mitigating damage from logging and blowdown;

4) the need to keep logging debris away from the stream; and

5) the probable transmission of impacts downstream.

This knowledge has allowed technical development of stream classification and treatment prescriptions for logging that are now being used to reduce the problems that historically caused serious stream impacts.

Q3. Is the ocean habitat threatened by pollutants such as dioxins and could such pollutants be contributing to the decline in wild coho?

A3. The sampling programs for dioxin undertaken to date have found extremely small concentrations of dioxin in all species of adult salmon in specific locations. Dioxin is not, therefore, thought to be responsible for the broad decline in wild coho populations in the Strait of Georgia basin. There may be some local problems related to pulp mill

effluent discharges which do cause direct or sublethal effects to juvenile fish.

Q4. Is there any way to determine the production potential of a watershed for salmon and then develop an approach to apply the no-net-loss policy to protect against gradual loss of habitat over many years due to activities such as logging?

A4. At this time, there is no plan at the operations level of the Department to provide a basic accounting of habitat using no-net-loss procedures. To develop such inventory and mapping systems for each watershed would be both expensive and labour intensive, but could be done.

Several authors have examined ways of determining average production per unit of habitat for broad planning uses. An approach outlined by D. Marshall and E. Britton, entitled "Carrying Capacity of Coho Streams," described average levels of production (smolts/km.), sometimes referred to as biostandards. By using biostandards (approx. 1000 smolts/km.) and very elementary stream data (total length of channel), average smolt production estimates can be calculated and adult spawners determined based upon average egg/fry/smolt survival rates. Unfortunately, only about 10-15 percent of the Strait of Georgia watersheds have been mapped at the basic 1:50,000 scale required for habitat inventory reconnaissance. Without such maps, a biostandard production model cannot easily be calculated unless very broad assumptions are made. Since coho are small stream dependent, still more detailed levels of reconnaissance may be required to account for unmapped streams below the 1:50,000 scale.

The Department is, however, involved in the development of a comprehensive management plan for the Fraser River. As part of this work, a special habitat planning initiative is gathering all available information on Fraser River salmon production potential.

Q5. Is there a need to develop a long term land use strategy?

A5. Yes. There is a referral system for major projects in place, but referrals usually do not occur early enough in project planning. Therefore, the Department must take a more proactive approach to land-use planning and build cooperative links with other government agencies, corporations and individuals to ensure the protection of fish habitat.

Q6. What can be done to influence the actions of private property landowners?

A6. The Department is considering a three part program to protect fish habitats from the actions of private property landowners. The first part involves encouraging public awareness of fish and their needs through education and communication, using not only school programs, but also broader multi-media approaches designed to reach adult residents of the province. The second part involves strengthening federal-provincial cooperation in those regulatory areas in which private property development might impinge upon the rights of fish. In the third part, the Department will take an anticipatory role in regional district land-use decision-making through the development of a better referral process.

MANAGEMENT

Q1. How do the Department and the Provincial Fish and Wildlife Agency mandates differ?

A1. The Department is responsible for the protection and management of all fisheries throughout Canada, including tidal or salt water and salmon in fresh water. The Province is responsible for the protection, enhancement, and management of all freshwater fisheries, except salmon, in British Columbia. Legislative authority for both agencies, for conservation purposes, is provided by the Fisheries Act of Canada.

Q2. Who decides on the options?

A2. Management options put forward by user groups will be evaluated according to the criteria listed in Section 5.1 of this report, before being passed on, with recommendations, to PARC and the Minister of Fisheries for a final decision.

Q3. Why is Indian food fish the second priority?

A3. Native food fish requirements have been always been recognized as a priority subject only to conservation. Recent court decisions, most notably the Sparrow Decision, have strengthened and verified this policy.

Q4. Why have these declines in coho been allowed to occur?

A4. The declines in coho have definitely not occurred in the absence of a response by the Department and the public. Many terminal and in-river sport fisheries have been severely curtailed and all coho-directed commercial net fisheries have been effectively eliminated. Our habitat protection capability has been further supported through the development of the National Habitat Policy. Enhancement projects by government and the public have been targeted at rebuilding coho stocks in the Strait of Georgia for at least the past fifteen years.

The current situation is that, in spite of these efforts, the wild coho stocks in the Strait

of Georgia (including the Fraser River) continue to decline and are in need of additional measures to reverse the trend. The present initiative is designed to build on past actions and develop a comprehensive plan that will ultimately meet the objective of a healthy coho resource.

Q5. Why doesn't the Department study coho migration as it does sockeye migration?

A5. Stock distribution patterns for coho salmon are being studied by analyzing coded wire tag recovery data. The timing and location of the tagged coho catch provide evidence of the rearing and migration patterns which ultimately determine vulnerability to fishing gear. For sockeye salmon, parasites, scale pattern analysis and electrophoresis are used to identify stocks in fisheries. Although these biological marker techniques are superior to coded wire tagging in many respects, they are not effective in tracing coho movements.

Q6. How can we be sure that coho conservation measures taken by the sport fishery will be effective, given that chinook measures have not met their objective.

A6. The Department is committed to attaining whatever conservation goals are set for chinook or coho through an integrated process involving harvest and production management. The status of coho stocks will be evaluated on a continuing basis, as will the harvest impacts of all the fisheries.

In the case of the conservation program for lower Strait of Georgia chinook, specific measures were taken in the troll, net, sport and Indian fisheries to reduce their harvest rates by 20 percent. In the sport fishery, the harvest rate reduction was to be achieved by decreasing the annual bag, increasing the size limit, and expanding the area where the restrictions are applied to include Johnstone Strait. The approach was based on several assumptions, including expectation of fishing effort and estimated chinook abundance. A comprehensive evaluation of the effectiveness of the measures has not yet been carried out, as this is only the second year of the program and more time is required to complete the assessment. Preliminary analysis using coded wire tag information for 1989 only does not show a decline in harvest rate. The Department is conducting a more thorough evaluation using several methods to assess the reduction in harvest rate. Upon completion of this review, the Department will have a better idea of how well the assumptions made in implementing the sport reductions worked. If the necessary reduction has not been obtained, then further measures will have to be considered to meet the conservation objective.

Q7. What is the Department's surplus fish policy?

A7. To be considered surplus, the number of fish has to exceed or be expected to exceed spawning targets and Indian food fish needs. The Department does not manage for surplus fish, though specific stocks occasionally show a surplus. Proposals for harvest of surplus fish over and above food fish needs should be submitted to the Department for evaluation on a case by case basis.

Q8. Why doesn't this initiative apply to stocks on the whole coast, not just Strait of Georgia stocks?

A8. The present coho initiative examines escapement trends for most south coast stocks, including Johnstone Strait, Strait of Georgia and the Fraser River. However, information on exploitation rate analysis is only available at this time for Fraser River, Strait of Georgia, and west coast Vancouver Island stocks. Accordingly, it is proposed to address the concerns for Strait of Georgia and Fraser River stocks while completing the review for the other stocks, which would be initiated beginning in the fall of 1991. The alternative of delaying the present process pending completion of the exploitation analysis would likely result in further declines in coho stocks, necessitating even more severe restrictions to rebuild them. The present initiative, then, would be regarded as the first phase in a process that would eventually include all stocks on the south coast. For further details, please refer to Section 3.4.

Q9. Is salmon aquaculture a threat to wild stocks?

A9. At present, salmon aquaculture is not considered a significant threat to wild stocks because it is so strictly regulated. B.C. has been careful to ensure that imported eggs are screened for disease and undergo an isolation period. The bulk of the fish farmed are based on local natural stock, so diseases tend to result from the concentration of fish and be transmitted by local wild stock, rather than the other way round. However, the genetic implications of fish farms are still largely unknown and remain a concern.

Guidelines also control how and where fish are farmed and policy dictates no fish releases from fish farms. It is not yet known whether inadvertent releases of fish from fish farms may prove to be a problem. So far, the Department has found that the incentive seems to be to maintain rather than to release fish. When farms declare bankruptcy, the Department is called in to deal with the fish, which may be destroyed.

The Department is very careful to ensure that fish farms are well sited to minimize the damage to the ocean floor that can be caused by poor flushing of water through the area. Fish farmers also have a fairly strong incentive to site their farms properly, since otherwise the organic sludge build-up on the ocean floor will produce hydrogen sulphide that poisons the farmed fish as well as other marine life in the vicinity.

Q10. Don't the driftnets catch a majority of the coho, thus making these efforts futile?

A10. Data from high seas tagging operations and high seas recoveries of coded wire tags indicate that coho salmon produced in British Columbia migrate as far as the Gulf of Alaska (area A in Figure 4). This migration pattern keeps this species of salmon away from both the Japanese salmon directed driftnet fishery (area B) and the squid driftnet fisheries of Taiwan, South Korea, and Japan (area C).

Q11. What is the Department doing about driftnets?

A11. Canada has been extremely active in efforts to better understand and control the high seas driftnet fisheries. This country will play a key role in the resolution of this important issue and has initiated a number of actions to this end, including the four examples listed below.

a) Canada launched multilateral discussions with Japan, South Korea, and Taiwan regarding measures to control, monitor and enforce these countries' domestic regulations regarding driftnet fishing. These discussions have led to an agreement with Japan for Canadian observer coverage in the squid driftnet fisheries (5 observers in 1989 and 10 observers in 1990), increased enforcement patrols and installation of transponders for real time satellite tracking.

b) Research activities include the initiation of a scientific working group to explore the impact of driftnet fishing and the development of alternative fishing technology. In addition, Canada has sponsored a number of research cruises in the northern area of the squid driftnet fishery to obtain more information on the number and origin of salmonid catches, incidental catch of mammals and sea birds, and incidents of discarded driftnets.

c) Enforcement programs aimed at addressing the illegal import and export of salmon caught on the high seas are continuing. In addition, aerial surveillance programs in the North Pacific carried out in cooperation with the Department of National Defense are being increased.

d) Canada has co-sponsored a U.N. General Assembly resolution which calls for a ban on driftnet fishing by 1992 unless it can be proven scientifically that driftnets are not harmful. To this end, Canada has offered to sponsor a scientific review meeting to address the impacts of driftnet fishing.

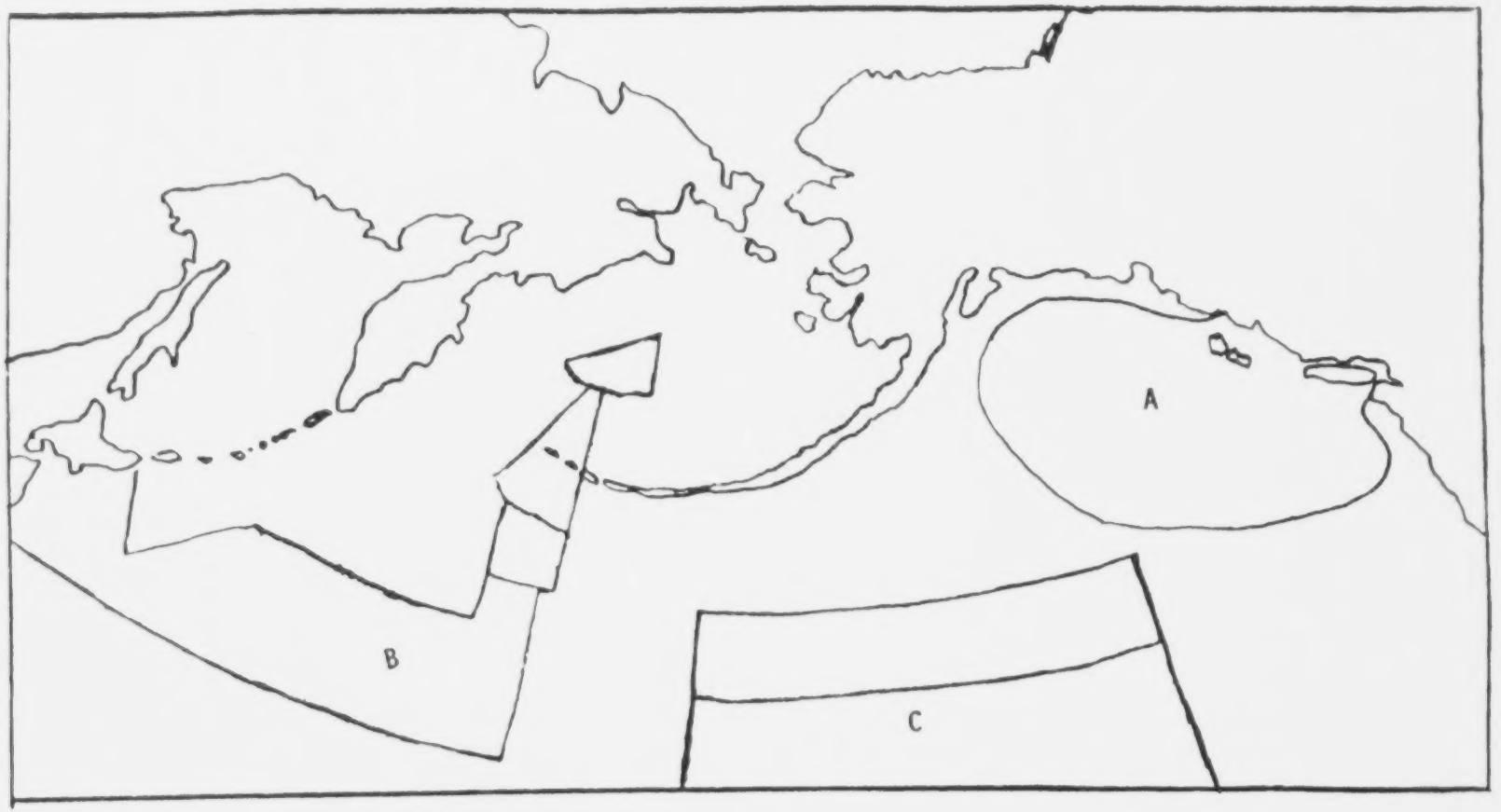



FIGURE 4 MAP OF NORTH PACIFIC OCEAN WITH LOCATION OF SALMON-DIRECTED AND SQUID-DIRECTED DRIFTNET OPERATIONS

Area A - Known distribution of B.C. coho.

Area B - Salmon Directed Driftnet Operations

Area C - Squid Directed Driftnet Operations

## EVALUATION

Q1. Was the 1989 catch in Juan de Fuca Strait an anomaly?

A1. The 1989 coho catch of 341,000 in the Juan de Fuca net fishery was anomalous in that it was the highest catch in this fishery since 1977. However, there have been five intervening years when the catch has exceeded 200,000 fish; most recently, in each year from 1985 to 1987. In the 24 years from 1953 to 1976, the catch in this fishery exceeded the 1989 level 15 times. The reduced catch in recent years is due primarily to the elimination of the late season directed coho fishery.

The seasonal pattern of the 1989 catch was anomalous relative to other recent years in two respects. First, there was an extremely high catch very early in the season (during the third week of July) of 50,000 fish. In Juan de Fuca Strait, weekly catches in excess of 1,000 fish are very rare prior to the first week of August. This rarity reflects the usual lack of coho in the area at this time and the limited net fisheries prior to August. Secondly, there was a directed coho harvest of 23,000 fish in the last week of September in response to a U.S. directed coho fishery in the San Juan Islands and Point Roberts area. This response fishery also occurred in 1987.

Q2. How does the fact that most of the data used in the analysis came from the pre-treaty period affect the results?

A2. The Pacific Salmon Treaty did not have a significant direct effect on Strait of Georgia (including Fraser River) coho stocks. The west coast of Vancouver Island troll fishery ceiling would have marginally reduced the exploitation rate on these stocks in perhaps two or three years. Offsetting this reduction, however, are periodic late season chinook non-retention fisheries, which have probably increased harvest rates somewhat.

Indirect effects on coho may be more significant than the direct effects. Chinook conservation measures associated with lower Strait of Georgia chinook rebuilding may have had an adverse effect on coho by redirecting fishing effort from chinook to coho. The directed coho fisheries in Juan de Fuca Strait in 1987 and 1989 in response to U.S. fisheries at Point Roberts harvested mainly U.S. coho, but a small component of Strait of Georgia coho were also present in the catch.

Q3. How are you going to measure and monitor harvest rates?

A3. Fishery harvest rates cannot be measured directly, but will be estimated using coded wire tag catch distribution profiles and exploitation rate estimates for key stocks. The exploitation rate on Robertson Creek coho provides an approximation of the harvest rate of the west coast of Vancouver Island troll fishery (the main fishery in which it is caught). Stocks that are caught in outside fisheries at a higher rate tend to experience lower over-all exploitation rates than those which are caught primarily by

inside fisheries (e.g. Thompson River, Robertson Creek). These factors, combined with the exploitation rates on Strait of Georgia stocks, will all be used in the estimation procedure.

## 3.2 FISHERIES MANAGEMENT MODELS

In response to the sport advisors' many questions about the models used in estimating the effects of different harvest rates on fish populations, a meeting was arranged with the Department of Fisheries and Oceans/Sport Fish Advisory Board (SFAB) Statistics Committee on January 15, 1991. Time constraints kept the meeting short and explanatory. It was agreed that in-depth examination of the models would be postponed until a later date. This section summarizes the information presented by the Department at the meeting and provides the gist of committee members' comments.

### THE DEPARTMENT'S PRESENTATION

Fisheries management models are based on discrete fisheries that can be managed as a unit. These models predict the effects of a particular management action on the harvest rate in a particular fishery. They cannot, however, predict the effect of the management action on the exploitation rate for the stock unless the distribution of the stock and the impacts of all the other fisheries which harvest the stock are known. Models which predict the effects of management actions on harvest rates in individual fisheries must, therefore, be "linked" together by a model describing the movement of fish between fisheries, and all fisheries must be included. Without such models, the effects of harvest rate changes on stock exploitation rates cannot be evaluated. In fisheries that harvest Strait of Georgia coho, the Department uses three types of models: Hook and Line, South Coast, and Linking.

#### Hook and Line Models

Hook and Line Models assess the impact of regulatory changes for the west coast Vancouver Island troll fishery, the Strait of Georgia troll and sport fisheries, and the Juan de Fuca sport fishery. These models are designed to estimate harvest rate changes for chinook and coho (as well as sockeye, pink and chum) in these fisheries, and can evaluate a complex range of management options, such as the effects of time and area closures, size limits, annual and daily bag limits, catch ceilings and effort limits. It is important to recognize that these models are designed to assist in determining the relative effects rather than to predict the actual effects of harvest rate changes.

There are two main parts to the development of each Hook and Line Model. In the first part, fishing information from previous years is used to construct a model of the fishery in each of those years. In the second part, the effects of various management actions on the fishery in those years are simulated. The first part, which is called a cohort analysis, must be very carefully done because it provides the basis for the simulations in the second part.

Cohort analyses have been completed for 1983-1989 for the Straits of Georgia and Juan de Fuca Hook and Line Models and for 1979-1989 for the west coast Vancouver Island troll fishery.

A cohort analysis is the detailed examination and reconstruction of the life history of a fish population. It involves, among other things, tracking the fish population's mortality and emigration rates. Figure 5 shows the sorts of information that would be needed to do a cohort analysis for coho salmon.

A cohort analysis makes two things possible: the calculation of the starting cohort (fish population) size and the estimation of catchability coefficients. The catchability coefficient is the relative vulnerability of fish to fishing gear and is determined by:

$$\text{Relative Vulnerability} = \frac{\text{Catch}}{\text{Cohort Size x Fishing Effort}} \quad (1)$$

The catch and the fishing effort are known from fishery data, but cohort size is unknown. Cohort size can be calculated by:

$$\text{Cohort}_{\text{next time}} = \text{Cohort}_{\text{this time}} - \text{Losses} \quad (2)$$

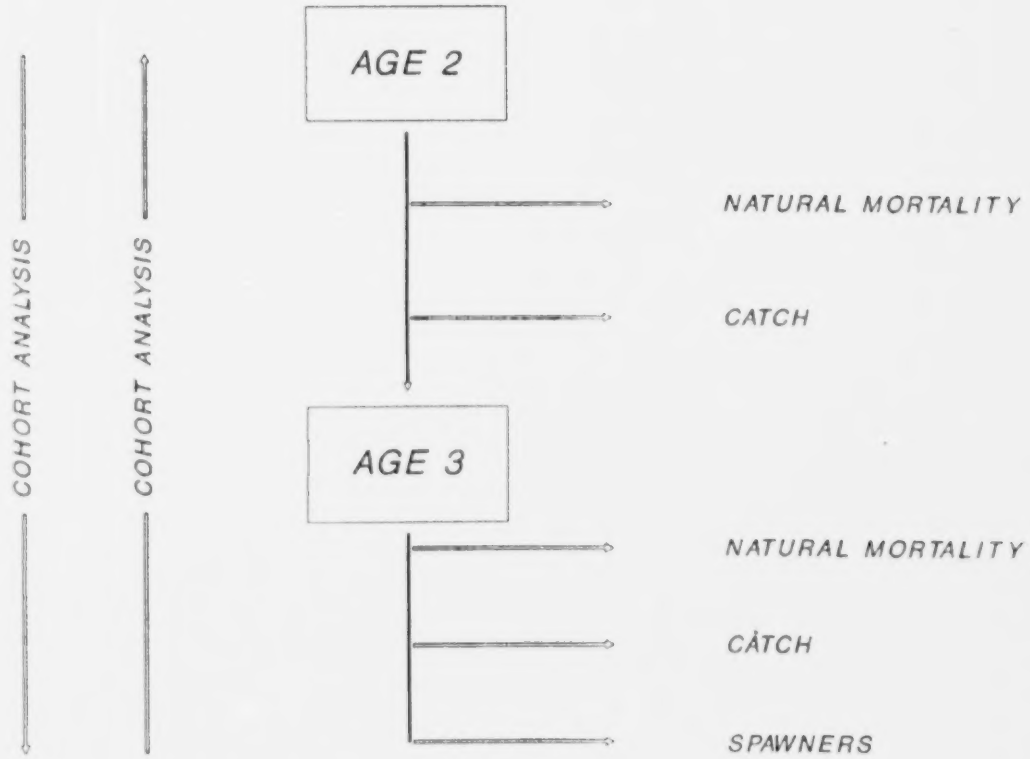
Losses from the cohort occur through fish caught, spawning escapement, natural mortality, fishing induced mortality (fish shaken from hooks) and emigration of fish to another cohort. The change in cohort size during each weekly time period can be computed using estimates of each of these losses. $\text{Cohort}_{\text{this time}}$ is a much more complicated calculation since it is difficult to know what cohort size to begin with. Starting cohort sizes can be estimated from downstream smolt counts, but such estimates are very rough because almost all the losses during the first few months of ocean life are due to natural mortality, which is extremely difficult to estimate. The sensitivity of model results to starting cohort size and natural mortality rate make this approach very unreliable.

However, by modifying equation 2 to work backward in time rather than forward, cohort size can be determined with reasonable accuracy, since the last cohort size is usually known or at least close to zero.

$$\text{Cohort}_{\text{last time}} = \text{Cohort}_{\text{this time}} + \text{Losses During Last Time} \quad (3)$$

FIGURE 5

## INFORMATION NEEDED TO DO A COHORT ANALYSIS FOR COHO SALMON



Expanding this equation to itemize the various losses during each week in the years studied, we have:

$$N_{t-1} = N_t + C_s + C_c + D_n + SH + O + S \quad (4)$$

$N_{t-1}$ = cohort size at time t-1 (1 week earlier)
$N_t$ = cohort size at beginning of week
$C_s$ = sport catch
$C_c$ = commercial catch
$D_n$ = natural mortality
SH = shaker mortality
O = emigrants to waters outside the Strait of Georgia
S = spawners

This model assumes that the coho catch is composed primarily of 3 year old fish. Data for the variables come from a wide variety of sources. Sport and commercial catch are determined, respectively, from the Strait of Georgia creel survey and from sales slips. Natural mortality estimates are based on past studies. The number of fish killed through being shaken off hooks (shaker mortality) is calculated by multiplying the shaker mortality rate by the number of fish released. The shaker mortality rate is derived from empirical evidence and differs by salmon species as well as by fishing method (sport or commercial). The number of fish released is, in turn, estimated by:

$$\text{Number Released} = \frac{\text{Catch}}{\text{Proportion of Legal Size}} - \text{Catch} \quad (5)$$

The proportion of legally sized fish caught is calculated by a statistical procedure based upon measurements of fish of known age at various times throughout their lives. Coded wire tag returns provide information on the number of emigrants to waters outside the Strait of Georgia and the number of spawners is estimated from escapement data.

Once cohort size for each week has been determined, the catchability coefficient or relative vulnerability of the salmon to fishing gear can be calculated (equation 1). The weekly cohort sizes and catchability coefficients are used in the second part of the Hook and Line Model.

In the second part of the modelling exercise, the effect on harvest rate of a change in management action, such as the imposition of a daily bag limit, is simulated. For each simulation exercise, a "base year" is selected from the past fishery years reconstructed in the first part of model development. The base year chosen is the one in which conditions (such as high or low coho abundance) most closely resemble those of the year(s) in which the management action would be implemented. The model is then run forward by recalculating fishing effort and catch for each week of the year as a result of the management action.

In running the model forward, fishing effort is allocated by species, although an empirical

method for doing so is not currently known. For the sport fishery, therefore, effort allocation is based upon a subjective estimate of the desirability of different salmon species to sport fishermen. For the troll fishery, it is assumed that fishermen are trying to maximize their profits, so effort allocation is based upon species abundance and the relative value of particular species.

Once weekly fishing effort has been estimated, catch can be calculated using the cohort sizes and catchability coefficients worked out in the first part of the model. Equation 1 is rearranged to give:

$$Catch_t = N_t \times E_t \times q_t$$

where:

$Catch_t$ = catch at time t
$N_t$ = cohort size at time t
$E_t$ = effort at time t
$q_t$ = catchability coefficient at time t

Using this weekly catch together with spawning escapement estimates, the harvest rate resulting from the particular management action can then be calculated.

The Hook and Line Model can be used to simulate the effects of numerous management measures and is currently being modified to enable the analysis of marked only fisheries. The effects of small area closures, however, are difficult to accurately simulate because data on small areas have not been identified.

In the Hook and Line Models, a number of assumptions are made about the level of detail and the number of factors considered. Each of the models covers fairly discrete fisheries, but operates under different management scenarios. Each model run is based upon one calendar year and most calculations are made on a weekly basis. These weekly calculations allow for rapid feedback on the effects of changing fish abundance on subsequent fishing effort, as well as for accurate representations of the effects of different management actions. It was decided that no spatial resolution would be incorporated into the models, meaning that the Strait of Georgia is treated as a single mix of fishermen and fish. This decision was made because there are inadequate data available to follow the movement of fish from different fish stocks inside the model areas. Also, fishing effort was averaged for all sport and for all commercial fishermen. Yet another important assumption is that hatchery fish provide information on emigration and immigration of wild stocks in the various model areas. Finally, all modelling of the effects of management actions is based upon the assumption of 100 percent compliance on the part of user groups.

In discussing these Hook and Line Models, it should be recognized that they are decision-

making tools to be used in discerning the complex interactions between regulatory changes, fish abundance and distribution, and the diversity of fishing activities. They offer the benefit of clearly delineated assumptions which can be tested. They are, however, by no means perfect and are constantly being re-evaluated, revised and improved. A given model will be sensitive to some changes in variables, such as the effects of a change in fishing effort, but not to others, so it is important to determine the appropriate use for each model. Similarly, it is important to minimize the complexity of the model, since each new variable requires new and potentially erroneous assumptions to be made and introduces a host of new interactions which make it difficult to detect programming errors and parameter input errors, thereby affecting overall model performance.

## The South Coast Model

The South Coast Model is designed to predict the effects of regulatory change on the Johnstone Strait, Juan de Fuca, Strait of Georgia and Fraser River net fisheries. These fisheries are intended to harvest sockeye, pink and chum salmon (primarily those returning to the Fraser River) and handle coho catch in a fairly simple manner. This model evaluates harvest rate changes resulting from changes in fishing intensity. Other actions, such as gear restrictions and changes in boundaries, can still only be evaluated qualitatively. This model was not discussed in detail as it was designed primarily to manage sockeye.

## The Linking Model

A Linking Model has been developed to translate harvest rate changes in each of the major fisheries into exploitation rate changes for the west coast Vancouver Island stock and for each of the five Strait of Georgia and Fraser River coho stocks (northeast Vancouver Island, southeast Vancouver Island, Strait of Georgia mainland, lower Fraser River and Thompson River). A particular management action will be first evaluated using the appropriate fishery model to estimate the resulting harvest rate change, then the Linking Model will be used to estimate the ensuing change in the exploitation rate for each of the stocks of concern.

In using the Linking Model, the first step is to determine harvest rate, catch, stock abundance and escapement for each of the stocks of concern. Initial harvest rates for most hook and line fisheries are best guesses based on observed average exploitation rates and catch distribution patterns. Net fishery harvest rates are crude estimates based on the timing of coho migration relative to the timing of the individual fisheries. An index of catch is determined from coded wire tag recoveries, and indices of escapement and total stock abundance available to each fishery are estimated by:

$$\text{Escapement}_{fs} = \frac{(1 - \text{Harvest Rate}_f)}{\text{Harvest Rate}_f} \times \text{Catch}_{fs}; \text{ and} \quad (1)$$

$$\text{Total Abundance}_{fs} = \text{Catch}_{fs} + \text{Escapement}_{fs} \quad (2)$$

where:

$Escapement_{fs}$ = fishery escapement of stock s from fishery f
$Harvest\ Rate_{f}$ = harvest rate in fishery f
$Catch_{fs}$ = catch in fishery f of stock s
$Total\ Abundance_{fs}$ = proportion of stock s available to fishery f, with these exceptions:

1) where a fishery acts upon both rearing (pool) and migratory components of a stock, the catch of migrating fish is calculated by multiplying the harvest rate for migrating fish by the escapement from outside fisheries;

2) the pool catch is calculated as the observed proportion of the stock caught in the fishery minus the estimated migratory catch (harvest rates are adjusted so that the combined pool and migratory catches do not exceed the observed catch); and

3) terminal sport and Indian food fishery catches are not adequately sampled for coded wire tags, so $Catch_{fs}$ is unknown and is estimated by:

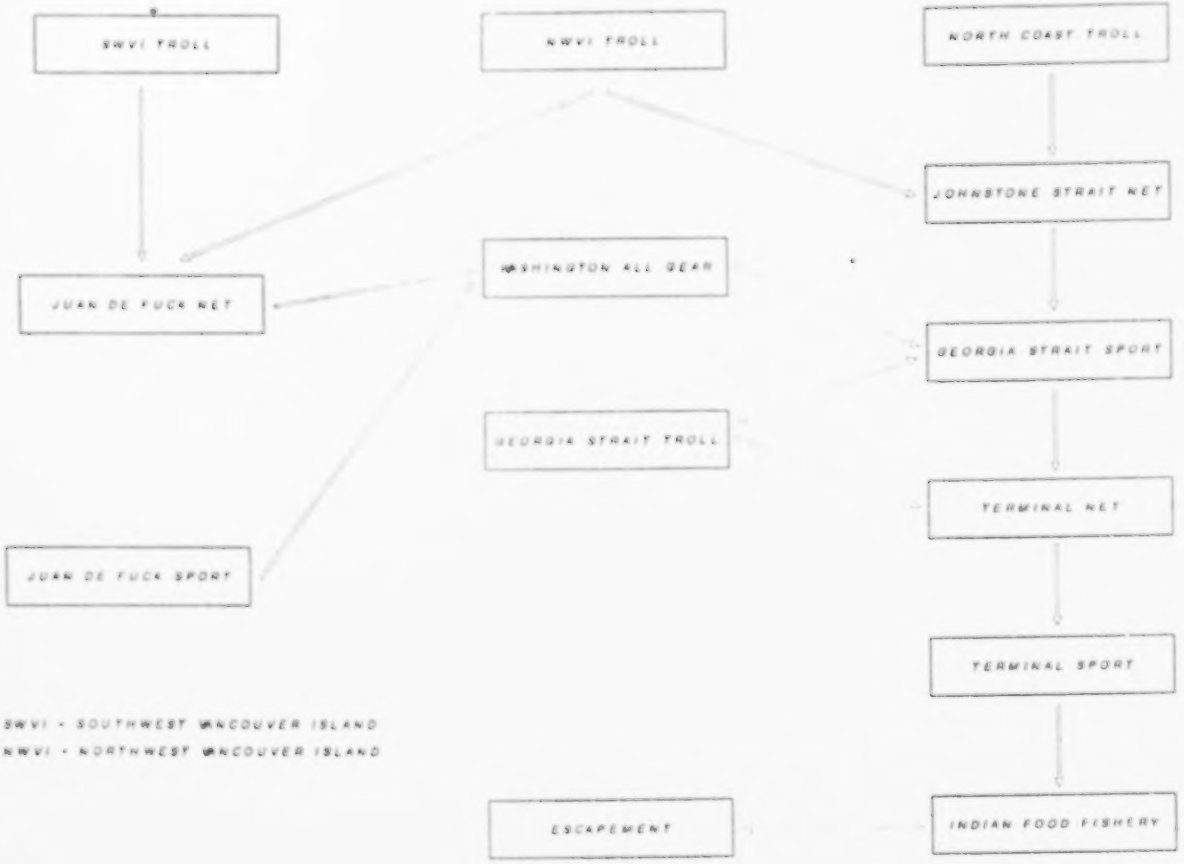
$$Catch_{fs} = Harvest\ Rate_{fs} \times Total\ Abundance_{fs}$$

where $Total\ Abundance_{fs}$ is estimated by summing $Escapement_{fs}$ for the appropriate fisheries.

The total stock available to each fishery will, however, be made up of varying numbers of fish from each of the stocks of concern. The distribution of fish from these stocks among the various fisheries is obtained through the analysis of coded wire tag recoveries. It is assumed that the pattern of these recoveries is an adequate representation of stock distribution even though the number of tags recovered in a fishery depends not only on the number of fish present (stock distribution) but also on the intensity of the fishery (harvest rate).

Figure 6 shows the movement of fish between fisheries in a schematic diagram which has been simplified so that the basic linkages between stock groups are the same. Approach net fisheries have been divided into two categories: migratory and pool fisheries. Migratory fish are moving through the fishery while pool fish stay to rear within the fishery area. It is assumed that the Strait of Georgia troll fishery does not catch migratory coho, only pool coho.

# FIGURE 6
# COHO LINKING MODEL
## MOVEMENT OF FISH BETWEEN FISHERIES




SWVI - SOUTHWEST VANCOUVER ISLAND
NWVI - NORTHWEST VANCOUVER ISLAND

The second step is to calibrate the model for a chosen base year. Calibration involves adjusting the harvest rates in each fishery to bring the exploitation rate for each stock group as close as possible to the observed exploitation rate (calculated from coded wire tag data) and then freezing stock sizes in outside troll and all pool fisheries. Variation of the harvest rates is carried out according to a few simple rules, which are outlined below.

1) The harvest rate in a fishery is the same for all stocks.

2) The harvest rates in the three outside troll fisheries are adjusted so that the calculated and estimated exploitation rates for west coast Vancouver Island stocks (Robertson Creek) are as close as possible to each other (most of the catch of Robertson Creek coho is taken in these three fisheries). Harvest rates in the northwest and southwest Vancouver Island troll fisheries are the same (and higher than or equal to the harvest rate in the north/central coast troll fishery because this fishery is believed to be less intense).

3) The harvest rate in the Strait of Georgia sport and troll pool fishery is then adjusted so that the modelled exploitation rate is as close as possible to the observed rate for the southeast Vancouver Island, northeast Vancouver Island and lower Fraser River stock groups.

4) In the approach net fisheries, pool fish harvest rates are higher than migratory fish rates, since the pool fish are rearing in the area and vulnerable to successive fisheries over a longer period of time.

5) Harvest rates for fish migrating through the approach net fisheries are based on South Coast Model estimates and adjusted so that the estimated catch does not exceed the observed catch.

6) The sport fishery harvest rate on returning spawners (Strait of Georgia migratory sport) is assumed to be low because maturing migrating fish are generally less vulnerable than young rearing fish and because spawning migrations tend to occur late in the year when sport fishing effort is low.

Adjusting the harvest rates means that catch and fishery escapement also need to be adjusted so they correspond to the changed harvest rates. Stock abundance is now considered fixed and catch and fishery escapement are calculated by:

$$Catch_{fs} = Harvest\ Rate_{fs} \times Total\ Abundance_{fs}; \text{ and} \quad (3)$$

$$Escapement_{fs} = Total\ Abundance_{fs} - Catch_{fs} \quad (4)$$

Stock distribution patterns are assumed to be fixed at the levels estimated before calibration since they should not be affected by harvest rate changes.

The model is now ready for use in estimating the effects of a changed harvest rate in each of the fisheries on the exploitation rates for the stocks of concern. After the change in harvest rate resulting from a proposed management action in a particular base year is calculated using the Hook and Line Model, this change is entered into the Linking Model. Step three, then, is to recalculate, based upon the changed harvest rate, the catches and exploitation rates for each stock. These new exploitation rates are then subtracted from the calibrated exploitation rate estimates to determine the resulting change in exploitation rate for each stock of concern. It is important to note that the total exploitation rate is actually higher than that shown in the model because terminal sport and Indian food fish catch data are excluded from the calculation of exploitation rate due to a lack of coded wire tag recovery data.

## THE COMMITTEE'S REACTION

Generally, SFAB representatives felt that the presentations made them feel more comfortable about the models and how they were used. They did, however, ask some specific questions about each of the models.

### Hook and Line Models

SFAB representatives' questions about the Hook and Line Model revolved around both the assumptions made in its development and its capabilities. They asked if fish abundances and distribution were assumed to remain the same and whether compliance had been taken into account. They also wanted to know whether there was any way of determining fish abundance by area.

The Department explained that abundance and distribution were not assumed to remain the same. The best case scenario of 100 percent compliance was assumed since model developers had not discussed non-compliance factors.

SFAB representatives asked about other implicit assumptions as well, such as whether harvest rates are assumed to be the same for all stocks. They wanted to know whether the model took into account fish that were recaught when the size limit was increased and whether fishing effort assumptions were changed when regulations or effort changed. They warned against the dangers of averaging catch figures, suggested that the method for allocating fishing effort between species needed improvement, and raised doubts about the accuracy of the calculation for shaker mortality. Finally, SFAB representatives asked what would happen if any of the assumptions were found to be incorrect and the model simulation proved inaccurate.

The Department explained that, while harvest rates are generally assumed to be the same

for all stocks, the model could be modified using stock composition estimates (where available) and time information to accommodate variable harvest rates among stocks. Recaught fish are incorporated into the model by increasing the abundance of the fish later in the season when the size limit is increased. While doubts were raised concerning the accuracy of the shaker calculation, the Department is satisfied that the current algorithm is logical and theoretically sound. Shaker to keeper estimates produced by the model are comparable to those observed in the different fisheries. Effort assumptions are not changed in accordance with regulatory changes, but could be. The Department acknowledged that a better method for allocating fishing effort was needed and stressed that the model was constantly being improved.

Questions about the capability of the model were varied. SFAB representatives wanted to know whether the model took into account all fish mortality and fish migration and they wondered about the sensitivity of the model to changes in fish abundance. They also asked how anomalies in fish runs were taken into account and whether the model had been tested against past events. Finally, they suggested that the model did have some predictive uses despite the Department's stress on its use solely as a monitor of relative change in harvest rate.

Reconstruction of the past year's fishery, the Department explained, makes natural mortality and migration estimations easier. The Department reminded committee members that the model can still achieve its purpose of determining the relative effect of management options if uncertainties such as natural mortality are held constant. The Department pointed out that unknown anomalies cannot be taken into account and agreed that the model should be tested against past events. At present, past lessons are used where appropriate and new conditions are incorporated wherever possible, so it could be said that the model has some predictive use, though no effort is made to forecast long term perturbations in the system. Ongoing evaluation of the model and correlation of management actions and their effects in the past with model results will be critical to the successful use of the model.

The South Coast Model

SFAB representatives asked why the harvest rate for chinook and coho in the approach net fisheries is assumed to be the same as that for target species. The Department explained that net harvest rates are based on distribution and size. Since coho are similar in size to sockeye, it is not unreasonable to expect mortality to be the same. Further, coho rearing in the area are probably more susceptible than sockeye moving through the area, so the harvest rate used in the model is probably an underestimate.

The Linking Model

SFAB representatives wanted to know if there was a trend in fish migration outside the Strait of Georgia, how the number of migratory fish was determined, whether a change in the seasonal pattern of fishing effort would affect harvest rate variables, and what sort of work was being done on the north coast.

The Department explained that no trend has yet been perceived in fish migration, but its highly variable nature is reflected in the model. The number of migratory fish used is a best estimate which could be changed if appropriate. The model shows harvest rate averages for the base year, so a shift in fishing effort and consequent change in coded wire tag sampling would be unlikely to have a significant effect. An initial stock assessment was done for Skeena River stocks (on the north coast) in 1988. More assessment work is required, but it is hampered by limited coded wire tag data and a lack of resources.

In closing, SFAB representatives stated that they would be satisfied with their examination of the fishery management models if they could provide the SFAB with a list of the key assumptions used in the models.

## 3.3 EVALUATION OF JOHNSTONE STRAIT NET FISHERY

This section responds to the commercial advisors questions about whether past regulations in the Johnstone Strait net fishery have affected the coho salmon harvest rate.

Net fisheries catching coho in Johnstone Strait are targeted on passing sockeye, pink and chum stocks. Since 1985, when the Pacific Salmon Treaty was signed, the coho catch in the Johnstone Strait net fishery has averaged 107,000 fish (1985 to 1989). This compares with an average of 185,000 in the previous five year period (1980 to 1984) and 151,000 between 1972 and 1979. Tables 2 and 3 and Figure 7 summarize Johnstone Strait (Statistical Areas 11-13) gillnet and seine days fishing, boat days fished, and coho catch for the period 1972 to 1989.

Changes in stock abundance combined with changes in the management approach for Johnstone Strait fisheries have altered the level and species composition of the catch in recent years. For example, while coho catches have declined in the most recent five year period, sockeye catches have increased because of very strong Fraser River runs.

The Johnstone Strait net fishing season is divided into two periods for management purposes: the summer sockeye and pink salmon period extends to the first or second week of September; and the fall chum period extends from the third week of September to early November.

# TABLE 2
## JOHNSTONE STRAIT GILLNET AND SEINE DAYS FISHING, BOAT DAYS AND COHO CATCH 1972-1989

| Year | Fishery Opening Date | Total Season | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Days Fishing | | Boat Days | | Coho Catch | | |
| | | Gillnet | Seine | Gillnet | Seine | Gillnet | Seine | Total |
| 1972 | June 11 | 59 | 59 | 12177 | 5521 | 32043 | 41593 | 73636 |
| 1973 | June 10 | 70 | 70 | 13472 | 8647 | 49027 | 96972 | 145999 |
| 1974 | June 16 | 45 | 45 | 7554 | 4576 | 39155 | 67330 | 106485 |
| 1975 | June 15 | 54 | 54 | 5209 | 4385 | 35808 | 80660 | 116468 |
| 1976 | June 13 | 54 | 54 | 8910 | 7133 | 64990 | 139562 | 204552 |
| 1977 | June 19 | 43 | 43 | 7510 | 6886 | 72744 | 154152 | 226896 |
| 1978 | June 18 | 46 | 46 | 8934 | 8394 | 62090 | 137740 | 199830 |
| 1979 | July 1 | 26.5 | 26.5 | 4671 | 4584 | 38186 | 97249 | 135435 |
| 1980 | June 29 | 26.5 | 23 | 6145 | 5041 | 34613 | 133028 | 167641 |
| 1981 | June 14 | 36.5 | 30 | 5170 | 5568 | 26757 | 174459 | 201216 |
| 1982 | July 4 | 33 | 25 | 7877 | 5705 | 50838 | 143404 | 194242 |
| 1983 | July 10 | 27.5 | 20 | 4958 | 5663 | 27050 | 216215 | 243265 |
| 1984 | July 15 | 18 | 14.4 | 3518 | 2703 | 24100 | 95004 | 119104 |
| 1985 | July 14 | 26.5 | 21 | 5924 | 4298 | 35575 | 111701 | 147276 |
| 1986 | August 3 | 20 | 13.4 | 7706 | 3181 | 42587 | 84124 | 126711 |
| 1987 | August 2 | 13 | 8 | 4644 | 2002 | 20460 | 40286 | 60746 |
| 1988 | July 24 | 14.3 | 10 | 5646 | 1921 | 21431 | 62875 | 84306 |
| 1989 | July 2 | 33.8 | 17.1 | 10384 | 3859 | 38094 | 78139 | 116233 |
| Average | | | | | | | | |
| 1972-79 | June 17 | 49.7 | 49.7 | 8555 | 6266 | 49255 | 101907 | 151163 |
| 1980-84 | July 2 | 28.3 | 22.5 | 5533 | 4936 | 32672 | 152422 | 185094 |
| 1985-89 | July 21 | 21.5 | 13.9 | 6860 | 3052 | 31629 | 75425 | 107054 |

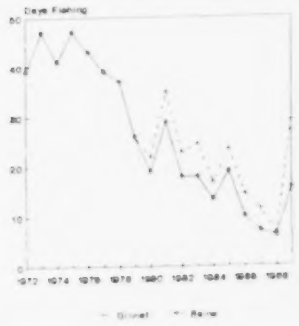
# TABLE 3
# JOHNSTONE STRAIT GILLNET AND SEINE DAYS FISHING, BOAT DAYS AND COHO CATCH BY MANAGEMENT PERIOD 1972-1989

| Year | Fishery Opening Date | Sockeye/Pink Management Period | | | | | | Chum Management Period | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Days Fishing | | Boat Days | | Coho Catch | | Days Fishing | | Boat Days | | Coho Catch | |
| | | Gillnet | Seine | Gillnet | Seine | Gillnet | Seine | Gillnet | Seine | Gillnet | Seine | Gillnet | Seine |
| 1972 | June 11 | 39 | 39 | 6229 | 2549 | 18901 | 23019 | 20 | 20 | 5948 | 2972 | 13142 | 18574 |
| 1973 | June 10 | 47 | 47 | 5431 | 3812 | 30226 | 70738 | 23 | 23 | 8041 | 4835 | 18801 | 26234 |
| 1974 | June 16 | 41 | 41 | 6092 | 3456 | 34703 | 63031 | 4 | 4 | 1462 | 1120 | 4452 | 4299 |
| 1975 | June 15 | 47 | 47 | 3264 | 2926 | 28006 | 67918 | 7 | 7 | 1945 | 1459 | 7802 | 12742 |
| 1976 | June 13 | 43 | 43 | 4369 | 4297 | 36365 | 119182 | 11 | 11 | 4541 | 2836 | 28625 | 20380 |
| 1977 | June 19 | 39 | 39 | 6472 | 6044 | 46924 | 125717 | 4 | 4 | 1038 | 842 | 25820 | 28435 |
| 1978 | June 18 | 37 | 37 | 6057 | 5349 | 31102 | 99399 | 9 | 9 | 2877 | 3045 | 30988 | 38341 |
| 1979 | July 1 | 26 | 26 | 4565 | 4472 | 17136 | 91668 | 0.5 | 0.5 | 106 | 112 | 21050 | 5581 |
| 1980 | June 29 | 22 | 19 | 3632 | 3454 | 21075 | 104130 | 4.5 | 4 | 2513 | 1587 | 13538 | 28898 |
| 1981 | June 14 | 35 | 29 | 4867 | 5288 | 21345 | 166440 | 1.5 | 1 | 303 | 280 | 5412 | 8019 |
| 1982 | July 4 | 23 | 18 | 4262 | 3259 | 32623 | 92963 | 10 | 7 | 3615 | 2446 | 18215 | 50441 |
| 1983 | July 10 | 24.5 | 18 | 4649 | 4931 | 20763 | 152586 | 3 | 2 | 309 | 732 | 6287 | 63629 |
| 1984 | July 15 | 17 | 13.4 | 3330 | 2486 | 22113 | 78122 | 1 | 1 | 188 | 217 | 1987 | 16882 |
| 1985 | July 14 | 23.5 | 19 | 4952 | 3610 | 31636 | 94698 | 3 | 2 | 972 | 688 | 3939 | 17003 |
| 1986 | August 3 | 14.5 | 10 | 6442 | 2015 | 27126 | 42925 | 5.5 | 3.4 | 1265 | 1166 | 15461 | 41199 |
| 1987 | August 2 | 11.5 | 7 | 3891 | 1640 | 17934 | 31639 | 1.5 | 1 | 753 | 362 | 2526 | 8647 |
| 1988 | July 24 | 6.5 | 6 | 1240 | 697 | 10156 | 43121 | 7.8 | 4 | 4406 | 1224 | 11275 | 19754 |
| 1989 | July 2 | 29.1 | 15.7 | 9449 | 3323 | 33724 | 60956 | 4.7 | 1.4 | 935 | 536 | 4370 | 17183 |
| Average | | | | | | | | | | | | | |
| 1972-79 | June 17 | 39.9 | 39.9 | 5310 | 4113 | 30420 | 82584 | 9.8 | 9.8 | 3245 | 2153 | 18835 | 19323 |
| 1980-84 | July 2 | 24.3 | 19.5 | 4148 | 3884 | 23584 | 118648 | 4.0 | 3.0 | 1386 | 1052 | 9088 | 33574 |
| 1985-89 | July 21 | 17.0 | 11.5 | 5194 | 2257 | 24115 | 54668 | 4.5 | 2.4 | 1666 | 795 | 7514 | 20757 |

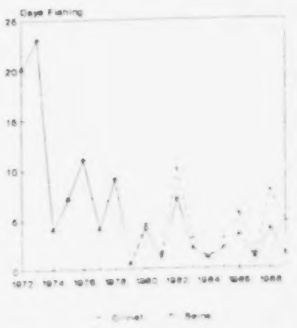
# FIGURE 7

# JOHNSTONE STRAIT NET FISHERIES

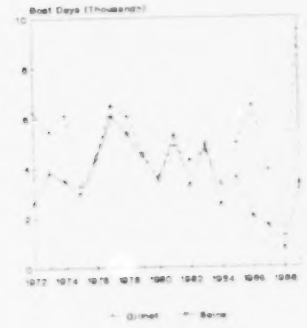
Johnstone St GN and SN Days Fishing
During Sockeye/Pink Mgmt. Period



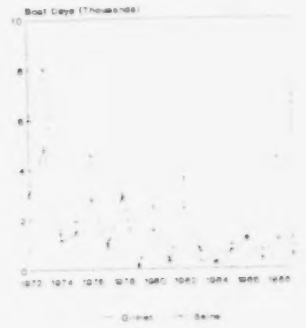

Johnstone St GN and SN Days Fishing
During Chum Mgmt. Period



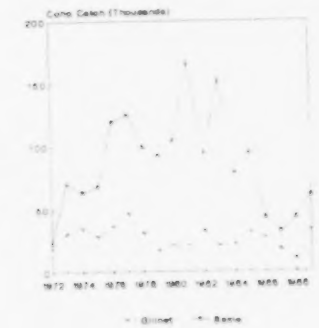

Johnstone St GN and SN Boat Days
During Sockeye/Pink Mgmt. Period



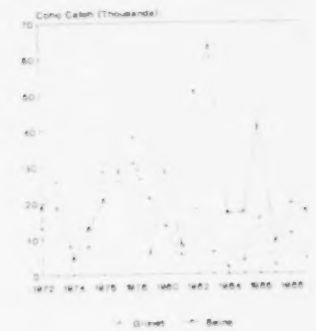

Johnstone St GN and SN Boat Days
During Chum Mgmt. Period




Johnstone St GN and SN Coho Catch
During Sockeye/Pink Mgmt. Period




Johnstone St GN and SN Coho Catch
During Chum Mgmt. Period



Prior to 1985, Johnstone Strait net fisheries maximized the catch of Fraser River sockeye and pink stocks prior to their migration into International Pacific Salmon Fisheries Commission (IPSFC) regulated waters. Local stocks were of lower priority and often suffered from the high harvest rates applied to Fraser sockeye and pink salmon. Johnstone Strait net fisheries in June, which harvested primarily coho, chinook and early season local sockeye, were curtailed for the first time in 1979, when the fishery opening date was delayed until July 1st.

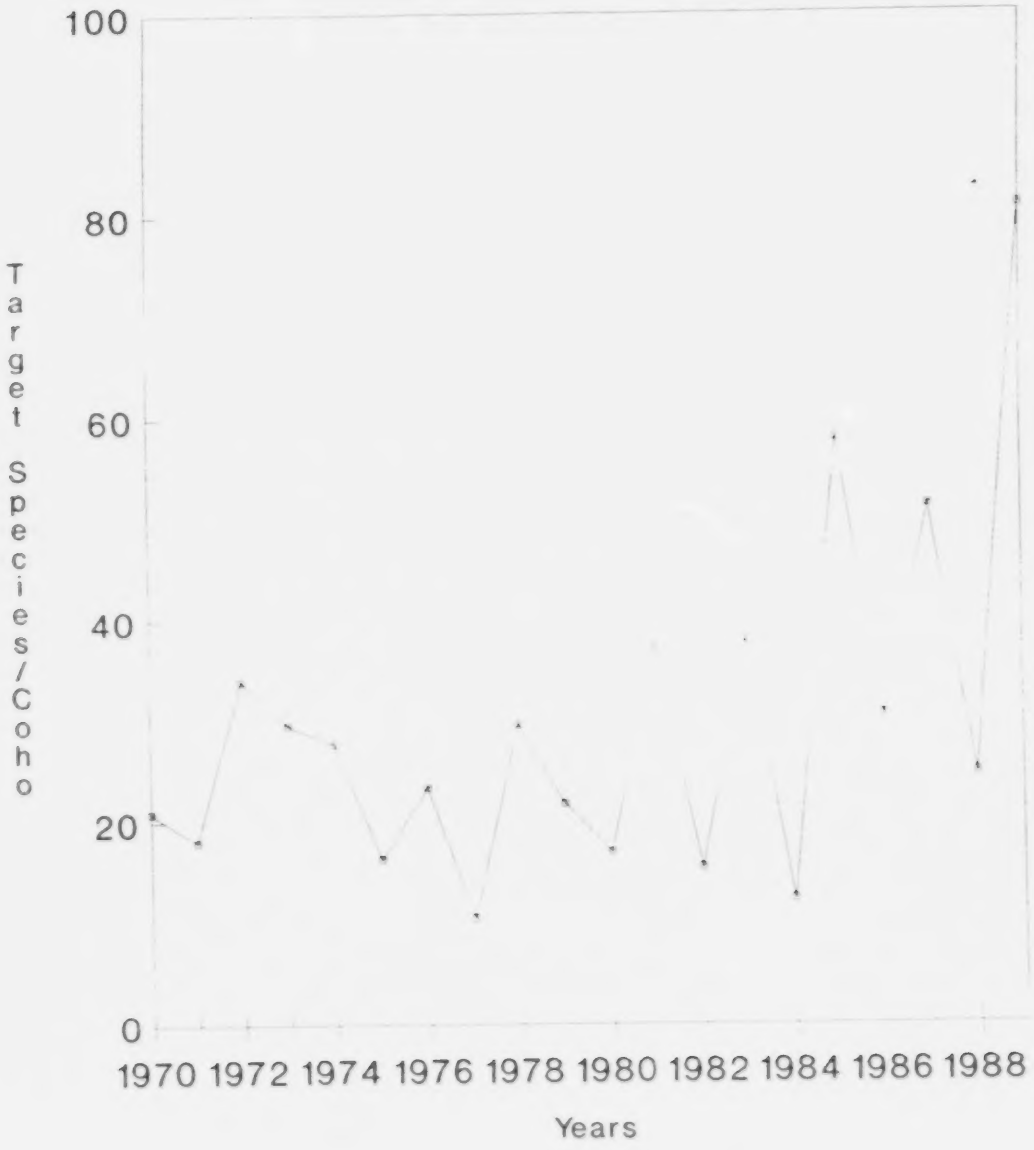
The 1985 Pacific Salmon Treaty meant that all Fraser sockeye and pink stocks catches were accounted for whether caught in the old IPSFC convention area or not. As a result of this change, target species catch allocations fell, with a corresponding drop in harvest rates, in the Johnstone Strait net fishery. From 1986 to 1988, therefore, seine fishing in Johnstone Strait did not open until the first week of August. These delayed openings have meant that the number of summer fishing days has declined sharply from the late 1970's to the present -- except in 1989, when fishing days were increased to accommodate an extended sockeye salmon fishing period and the late arrival of the Fraser River pink salmon run.

The reductions in fishing time coincided with a number of changes in fishery attributes. For example, the seine fishery's 51 percent reduction in fishing time from the 1970's (1972 to 1979) to the first five years of the 1980's coincided with a 6 percent reduction in boat days of fishing effort and a 44 percent increase in the coho catch. A comparison of the 1985 to 1989 period with the 1980 to 1984 period does, however, indicate that proportional reductions in fishing effort and catch occurred with the reduction in fishing time. For those years, on average, a 41 percent reduction in days fishing coincided with a 42 percent reduction in fishing effort and a 54 percent reduction in catch. The reverse of the seine fishery scenario occurred in the gillnet fishery. Reductions in fishing time from the 1970's (1972 to 1979) to the early 1980's (1980 to 1984) coincided with reductions in fishing effort and catch. Further reductions in fishing time in the late 1980's (1985 to 1989), however, actually coincided with an increase in fishing effort (due to an increase in fishing fleet size) and no change in catch.

Changes in management approach have also affected the Johnstone Strait fishery during the fall chum management period. In 1983, the clockwork chum salmon management strategy was introduced in Johnstone Strait. This strategy limited the chum salmon harvest rate by restricting the number of days fishing. On average, seine and gillnet fishing time and effort has declined since the clockwork strategy was introduced, but there has been no clear pattern in coho catches.

In addition to reducing the harvest rate on target sockeye, pink and chum stocks, recent management actions have resulted in the capture of a higher number of the target species for every coho caught (Figure 8). This change has occurred because fisheries are now more precisely scheduled to coincide with the migration timing of the target stocks.

# FIGURE 8
# JOHNSTONE STRAIT TARGET SPECIES/ COHO RATIO




Target species: sockeye, pink and chum

In addition to the previously mentioned adjustments in the Fraser sockeye and pink fishery, the 1985 Pacific Salmon Treaty required reductions in chinook salmon harvest rates in the Johnstone Strait net fishery as part of its coast-wide chinook rebuilding plan. Fishing plans were subsequently developed to reduce chinook salmon harvest rates by 25 percent from the rates of the base period (1979-82) to provide for the "pass through" of chinook escaping the restricted coastal troll fisheries. To accomplish this aim and to meet sockeye and pink harvest requirements, fishing times were restricted to periods of target species migrations. Openings where only small numbers of sockeye or pink salmon could be harvested were eliminated.

In spite of this initial 25 percent reduction in harvest rate, however, spawning escapements of lower Georgia Strait chinook stocks continued to decline. A further reduction in harvest rate of 20 percent was prescribed for all harvest sectors prior to the 1989 season. In Johnstone Strait, this requirement was translated into a 20 percent reduction from the number of fishing days in the brood year (1985 and 1986) to the number of fishing days in 1989 and 1990. Preliminary analysis indicates that for the 1985 to 1989 period, the harvest rate on lower Georgia Strait chinook stocks was reduced by an average of 33 percent over the base period (1979 to 1982).

It is apparent that the decline in fishing time during both the sockeye and pink management period and the chum management period since the 1970's did not coincide with consistent, proportional reductions in fishing effort and coho catch. Furthermore, the relationship between these fishery attributes and the coho harvest rate is very complex. It involves factors such as stock abundance, the rate of migration of fish through the fishing area, the proportion of a stock feeding or residing in the fishing area, the type and efficiency of fishing gear used, and the time of year of the fishery. As a further complicating factor, comparisons of fishery attributes between time periods when major management changes have occurred can be particularly difficult to interpret.

Despite these complexities, it appears that reductions in fishing time for seines since the early to mid-1980's have resulted in reduced harvest rates on coho. This conclusion is supported by the fact that effort has declined during both the sockeye/pink and the chum management periods since that time, and that harvest rates on chinook salmon appear to have declined as well. In contrast to the seine fishery, gillnet fishing times have not been curtailed because of the requirement to achieve their target species catch allocations. Although there is evidence for a recent, overall decline in the coho harvest rate in the Johnstone Strait net fishery, the magnitude of the decline cannot be quantified at this time.

### 3.4 JOHNSTONE STRAIT INCLUSION

This section responds to the sport fishery advisors' view that all coho stocks on the B.C. coast be taken into account in any fishery management actions taken by the Department. Specifically, the advisors requested that Johnstone Strait coho stocks be included in the current South Coast Coho Initiative to avoid the later need for another set of discussions

and regulatory actions for Johnstone Strait. They expressed willingness to delay implementation of the Initiative until Johnstone Strait had been included and formal stock assessments had been carried out throughout the B.C. coast.

The Department agrees that all coho stocks on the B.C. coast should be considered in setting fishery management regimes. In fact, the Department initially considered including Johnstone Strait coho stocks as part of the current initiative. Evaluation of the available data, however, revealed that a thorough stock assessment cannot be completed at this time for several reasons. The evaluation of spawning escapement trends, which will form a major part of the stock assessment, will require more intensive analysis than previously estimated. Data gaps already identified include the lack of accurate catch estimates for the Johnstone Strait sport fishery (which the Department will begin to address in 1991) and the lack of exploitation rate figures obtained from coded wire tag returns (which will require new collection programs). It is expected that still more data requirements will be identified during analysis of the available data, which will be a priority for this year.

Upon the expected completion of the Johnstone Strait coho stock assessment in 1992, discussions on the management needs of Johnstone Strait coho will be held as a logical continuation of the current initiative. This plan does not, however, diminish responsibility for addressing the Strait of Georgia and Fraser River coho conservation problem in a timely and effective manner. The consequences of delaying the implementation of any management actions until formal stock assessments are done throughout the B.C. coast (or even the south coast), will include a continuing decline in the catch of Strait of Georgia wild coho and an increasing reliance on hatchery fish. A continuing or even accelerating decline in Strait of Georgia wild stocks will, in the long run, necessitate more severe management measures than those currently under discussion.

## 4.0 IDENTIFYING MANAGEMENT OPTIONS

*The management measures and options presented in this section are preliminary and subject to change pending ongoing review and improvement of the fishery management models used.*

To achieve the required reduction in exploitation rate for Strait of Georgia and Fraser River coho stocks, regulatory measures will have to be implemented in both the commercial and sport fisheries. This section describes possible fishery management measures and then presents some management options which use combinations of these measures to achieve exploitation rate reductions.

Options presented in this section are examples only and should not be considered Departmental proposals. They are meant to provide a basis for the discussion of management options in the second workshop. Alternative suggestions and advice will be welcomed by the Department.

## 4.1 FISHERY MANAGEMENT MEASURES

### TIDAL SPORT FISHERY

#### Daily Bag Limit

The current daily bag limit for all salmon species combined is four fish per day. In most areas of south coastal B.C. only two of the four salmon can be chinook salmon. In a year of average coho abundance like 1987, the Georgia Strait sport fishery creel survey indicates that no coho were caught in almost three-quarters of the fishing trips made. In that year, seventeen percent of fishermen caught one coho, five percent caught two, two percent caught three and two percent caught the maximum of four coho per day. These statistics indicate that, given a similar abundance of coho, reduction of the daily bag limit to three and even two per day would have a small effect on the sport fishery harvest rate and catch.

In years of higher abundance, however, daily bag limit reductions would have a greater dampening effect on the sport fishery harvest rate, since more fishermen would likely catch three and four fish per day. Higher abundance occurs in years of high survival and/or when a high proportion of coho stay in the Strait of Georgia rather than migrate to the west coast of Vancouver Island or central B.C. Measures which might be taken to reduce the catch in the Strait of Georgia troll fishery would also result in an increase in abundance which could enhance the effect of bag limit reductions.

#### Seasonal Bag Limit

B.C. has no seasonal bag limit for coho salmon. The only seasonal salmon bag limit in place is for chinook salmon, which currently limits chinook catch in the Strait of Georgia to fifteen per year. Creel survey statistics for 1987 indicate that three-quarters of all sport fishermen catch five or fewer coho per year, while five percent catch more than fifteen per year.

As for the daily bag limit, a seasonal bag limit would be more effective in restricting harvest rate in years of high coho abundance than in years of low abundance.

#### Minimum Size Limit

The current minimum size limit for coho salmon in the sport fishery is 30 cm (12 inches). Coho reach this average size in November of their first year in the ocean. By the following

April they have reached 40 cm (16 inches). They then grow at a very fast rate through July and August and attain their maximum size of approximately 60 cm. (24 inches) in September.

Without a complementary means of restricting catch (such as daily or seasonal bag limits) minimum size limit regulations have the effect of delaying the catch rather than reducing it. Fish that are not caught because they are too small will grow until they reach the size limit and then be vulnerable to the fishery.

Shortened Fishing Season

Sport fishing for all salmon species is currently permitted year round. Although current regulations and the life cycle of coho salmon make them available to the fishery for the entire year, the vast majority of the coho catch occurs between April and September.

The effect of an early season closure would be much like that of increasing the size limit: the catch would be delayed rather than reduced. An early season closure would also, therefore, require a complementary catch restriction measure to dampen the higher catch rates that would occur later in the season.

A late season closure to protect fish just prior to spawning can be effective in reducing harvest rate, since subsequent fishing pressure is confined to terminal or in-river fisheries. However, the varied timing of the runs of different coho stocks would mean that the benefits of this type of regulation would be applied unevenly (some stocks would benefit more than others).

Gear Restrictions

Apart from a few measures in very small areas near river mouths, there are currently no specific sport gear restrictions for any salmon species. Fishing gear and methods used to catch coho vary widely between areas and fishermen, with no clear consensus on which method is the most effective. The effect of gear restrictions cannot be quantitatively assessed with present methods of assessment. Gear restrictions are also difficult to enforce, since in most cases enforcement would require laborious checking of terminal gear.

Spot Closures

Although spot closures have been used extensively for chinook salmon conservation in the Strait of Georgia, their effectiveness for coho conservation is questionable. Fish saved during a closure are likely to remain in, or near, the area and become vulnerable to the fishery again when it reopens. Higher catch rates could negate the effect of the spot closure unless the area were very large and the time in effect were long and/or near the end of the

period when coho are most vulnerable to the fishery (August/September). As with gear restrictions, there are difficulties in predicting and evaluating the effectiveness of spot closures.

### Marked Only Fishery

*A fishery management model to evaluate marked only options has only just been developed. A thorough analysis of marked only options could, therefore, not be included in this report, but will be made available as soon as possible.*

Currently, only a portion of hatchery fish (about 5 percent) possess an identifiable mark (adipose clip indicating the presence of a coded wire tag). Wild fish from a few study sites around the Strait of Georgia are also marked in the same way. Recoveries of these tagged fish provide assessment information to hatchery and fishery managers and researchers on the catch distribution, marine survival, fishery contribution, and exploitation rate of the tagged stock. Coho produced in the U.S. are marked in the same way.

The concept of a marked only fishery requires that all coho produced from Canadian hatcheries be visibly marked. Canadian hatchery coho currently account for 35 to 50 percent of the sport fishery catch in the Strait of Georgia. In a marked only fishery, sport fishery regulations set a higher bag limit for marked fish than for unmarked fish, resulting in a higher harvest rate for hatchery fish than for wild fish. Wild fish would be conserved, while hatchery benefits would increase, with fewer fish returning to the hatcheries where their market value is low. Most U.S. origin fish would not be marked and would be included in the wild bag limit, thereby further reducing the harvest rate on the wild stocks of concern.

Unfortunately, there are some disadvantages to this concept. Fishing induced mortality would be increased and the catch of U.S. fish would be lost. As well, hatchery coded wire tag data are currently the primary source of exploitation rate estimates for wild coho stocks in the area around the hatcheries. Although a mark other than the adipose fin could be used to identify hatchery fish, confusion could result from the multiple marks that would be necessary to achieve all the assessment objectives. This management approach has been used for steelhead in freshwater, but has not been tried on salmon in the ocean.

## COMMERCIAL FISHERIES

### Troll Fisheries

### Fixed Catch Ceilings

Fixed catch ceilings associated with a pre-determined fishing season have been implemented to control the catch of chinook and coho stocks under the Pacific Salmon Treaty. Under this approach, fisheries are either closed altogether or the retention of the species of concern is no longer permitted when a catch ceiling is reached. If the season ends before the catch

ceiling is reached, no further fishing is permitted.

The west coast of Vancouver Island troll fishery is the only troll fishery under a coho catch ceiling; the ceiling has been set at 1.8 million fish since 1987. In years of high abundance, like 1989, the ceiling is reached after less than two months of fishing, while in years of low abundance, like 1988, the ceiling may not be reached even with a longer fishing season. This points out one of the difficulties with using fixed catch ceilings to control fishery harvest rates: in years of high abundance, harvest rate reductions will be greater than in years of low abundance, even though the need for stock conservation may not be as urgent.

In cases where pre-season abundance forecasts are poor, or non-existent, as for Strait of Georgia coho, fixed catch ceilings which provide the required average harvest rate reduction may be implemented.

Variable Catch Ceilings

An alternative approach to fixed catch ceilings are catch ceilings which can be varied with fish abundance. This approach requires a pre-season forecast of abundance which, when combined with a particular catch ceiling, will result in the desired harvest rate being exerted on the fish present in the fishing area. For example, catch ceilings in ocean troll and sport fisheries in Washington and Oregon are set annually and are dependant upon pre-season estimates of run size.

Effort Limitation

This approach is based upon the relationship between fishing effort and harvest rate, and is largely independent of abundance. Measures of fishing effort include: a) the number of days of fishing if fleet size is fairly constant and there is only one target species; b) the number of boat-days (one boat-day is equivalent to one boat fishing for one day) if there is only one target species; and c) coho directed boat-days in a multi-species fishery.

Effort limitation controlling the number of fishing days was first used in 1990 in the management of chinook salmon in the west coast Vancouver Island troll fishery. Although there are technical difficulties in implementing this approach (such as measuring species directed effort), they are not insurmountable. Further feasibility assessment could be conducted if this approach were considered desirable.

Gear Restrictions

Commercial trollers are limited to six power gurdies, but the number of lines on terminal gear is unrestricted. The type or size of hooks and lures used is also unrestricted. As with the sports fishery, the effectiveness of different types of terminal gear is currently unknown. As with the sport fishery, enforcing gear restrictions is difficult.

Area Closures

Area closures have been used in the west coast of Vancouver Island troll fishery to increase and decrease the rate of coho and chinook catch in years of high and low abundance, respectively. When area closures are used in this way, it takes longer to reach the catch ceiling and an orderly harvest of other salmon species occurs without the need for periods of coho non-retention, with their inherent associated mortality. For coho, the specific areas where closures would be effective are highly variable between years, making pre-season planning very difficult. Therefore, area closures alone are not likely to be consistently effective from year to year.

Net Fisheries

Effort Limitation

Net fisheries are managed primarily by limiting fishing effort to achieve harvest rate or catch objectives. The number of fishing days per week (and, therefore, fishing effort) can be restricted based upon weekly forecasts of fleet size combined with relationships between effort and harvest rates.

It should be noted in evaluating effort limitation options that reduced effort should not only reduce the harvest rate on coho but also reduce the catch of other species. In the net fisheries harvesting Strait of Georgia coho salmon, the foregone catch of other species can be quite high.

Area Closures

Coho are generally distributed throughout the major net fishing areas. Small area closures aimed at reducing the harvest rate on coho salmon will most likely redirect fishing effort into other areas where coho are equally abundant, resulting in a minimal reduction in harvest rate. In addition to their questionable effectiveness, area closures cannot be evaluated quantitatively with the data available.

Gear Restrictions

Seine and gillnet gear are designed to capture all species of salmon. Their effectiveness in capturing different species and sizes of fish can be modified, however, by making adjustments to some of the physical attributes of the gear. For example, the catch of juvenile salmon was reduced by increasing the bunt mesh size of seines from 2.5 inches to 4 inches. Gillnet mesh size is routinely regulated to ensure that it is optimal for the target species. For adult coho, net fishery gear restriction does not appear to be a viable approach to reducing harvest rate. Net fishery target species like sockeye, pink and chum salmon are probably not sufficiently different from coho in their key physical characteristics to permit selective harvest.

Incidental Catch Ceilings or Ratio Limits

Incidental catch ceilings can control the catch of non-target species like coho in net fisheries by terminating the fisheries once the catch ceiling is reached. Although effective in limiting the incidental catch, this measure may also prevent a full harvest of target species like sockeye, pink and chum. Incidental ratio limits are more flexible in this regard, because they permit fisheries to continue as long as the incidental species comprises less than a predetermined proportion of the total catch. This discourages the catch of the incidental species but may still permit a full harvest of the target species.

## 4.2 FISHERY MANAGEMENT OPTIONS

Specific options for reducing harvest rates in their respective fisheries were offered by neither the commercial nor the sport sector at the first workshop. The Department hopes to discuss a wide range of management options with the advisors during the second workshop. To this end, the Department has prepared examples of management packages which meet or nearly meet management objectives for Strait of Georgia coho. It is emphasized that these are examples, not recommendations. A variety of management actions will reduce the harvest and stock exploitation rates by the required amount, and discussion on alternative approaches is welcomed.

As discussed in Section 5.1, the models used to evaluate options estimate the impact that management regimes would have had under historical patterns of abundance, distribution and effort. Regulations based on average levels of catch (such as ceilings and bag limits) are less effective when abundance is low. As coho stocks rebuild and new enhancement efforts take effect, these regulations will, on average, be more effective and will require re-evaluation.

The Department has examined three options for distributing harvest rate reductions between the sport and commercial sectors:

1) equal sport and commercial fishery reductions;
2) commercial fishery reduction larger than sport fishery reduction; and
3) Sport fishery reduction larger than commercial fishery reduction.

The first two options offer alternative approaches to restricting commercial fisheries. One approach involves equal harvest rate cutbacks in all major commercial fisheries, including the west coast Vancouver Island and south-central B.C. troll fisheries, approach net fisheries, terminal net fisheries and Strait of Georgia troll fisheries. While this approach shares the conservation burden, the sharing of foregone catch is not necessarily equal. The west coast Vancouver Island troll fishery must forego significant numbers of U.S. origin coho, while reductions in approach and terminal net fishing times may result in foregone catch of sockeye, pink and chum.

As an alternative, the Strait of Georgia troll fishery could take on the majority of the commercial coho harvest reductions and be compensated by an additional allocation of sockeye. This allocation of sockeye could be drawn from the other commercial fisheries which would not have taken as large a coho harvest rate reduction as under the equal reduction approach. The value of reallocated sockeye in this alternative would be substantially less than the value of foregone catch in an equal distribution of coho harvest rate reductions. Over the longer term, increased sport licence fees could be used to buy back Strait of Georgia troll licences, providing increased access to both chinook and coho for Strait of Georgia anglers.

Johnstone Strait and Juan de Fuca sport fisheries have not been included in these analyses. It may be prudent to apply the same regulations to both the Strait of Georgia and Johnstone Strait sport fisheries. This measure could simplify enforcement and reduce interception of the stocks of concern in the Strait of Georgia and the Lower Fraser. The Juan de Fuca sport fishery, on the other hand, harvests about 10 percent of the total Strait of Georgia sport catch, and most of these are of U.S. origin. The regulation of both these sport fisheries can be discussed in the second workshop.

The examples described above are summarized below, and detailed in the Appendix. For simplicity, the Johnstone Strait, Juan de Fuca, Georgia Strait and Fraser River net fisheries have been combined in the summary into a single fishery using simple numerical (unweighted) averages. For a more thorough review of fishery impacts on the net fisheries, please turn to Appendix 1. Readers are reminded that these examples do not constitute recommendations for regulatory measures in any fishery.

## *COMMERCIAL REDUCTION EQUAL TO SPORT REDUCTION*

## *OPTION 1: A AND B*

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***1A MANAGEMENT MEASURES:***

*ALL FISHERIES REDUCED*
*WEST COAST VANCOUVER ISLAND (WCVI) TROLL CEILING: 1.5 MILLION*
*STRAIT OF GEORGIA (GS) TROLL CEILING: 155,000*
*NET FISHING TIME REDUCED BY ABOUT 15%*
*GS SPORT FISHING LIMITS: 2 FISH PER DAY, 50 CM SIZE*

| | WCVI TROLL | GS TROLL | NET | GS SPORT | COMMENTS |
|---|---|---|---|---|---|
| HARVEST RATE | -14% | -15% | -15% | -14% | SIGNIFICANT FOREGONE COMMERCIAL CATCH (SOCKEYE,PINK,CHUM,& U.S. ORIGIN COHO) |
| COHO CATCH | -17% | -16% | -2% | -21% | |

***RESULTS:***

*ESCAPEMENT INCREASES BY 41%*
*EXPLOITATION RATE DECREASES BY 10 PERCENTAGE POINTS*

***1B MANAGEMENT MEASURES:***

*COMMERCIAL REDUCTION TAKEN BY GS TROLL*
*GS TROLL NON-RETENTION*
*GS SPORT FISHING LIMIT: 2 FISH PER DAY*

| | WCVI TROLL | GS TROLL | NET | GS SPORT | COMMENTS |
|---|---|---|---|---|---|
| HARVEST RATE | -0% | -93% | -0% | -9% | LITTLE FOREGONE CATCH |
| COHO CATCH | -0% | -100% | +12% | -17% | |

***RESULTS:***

*ESCAPEMENT INCREASES BY 42%*
*EXPLOITATION RATE DECREASES BY 10 PERCENTAGE POINTS*

## *COMMERCIAL REDUCTION GREATER THAN SPORT REDUCTION*

### *OPTION 2: A AND B*

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***2A MANAGEMENT MEASURES:***

*ALL COMMERCIAL FISHERIES REDUCED EQUALLY*
*WEST COAST VANCOUVER ISLAND (WCVI) CEILING: 1.4 MILLION*
*STRAIT OF GEORGIA (GS) TROLL CEILING: 120,000*
*NET FISHING TIMES REDUCED BY APPROXIMATELY 20%*
*GS SPORT FISHING LIMIT: 2 COHO PER DAY*

| | WCVI TROLL | GS TROLL | NET | GS SPORT | COMMENTS |
|---|---|---|---|---|---|
| HARVEST RATE | -20% | -30% | -20% | -2% | SIGNIFICANT FOREGONE * COMMERCIAL CATCH (SOCKEYE,PINK,CHUM & |
| COHO CATCH | -26% | -30% | -8% | -6% | U.S. ORIGIN COHO) |

***RESULTS:***

*ESCAPEMENT INCREASES BY 32%*
*EXPLOITATION RATE DECREASES BY 8 PERCENTAGE POINTS*

***2B MANAGEMENT MEASURES:***

*MOST COMMERCIAL REDUCTIONS TAKEN BY GS TROLL*
*GS TROLL NON RETENTION*
*WCVI TROLL CEILING: 1.7 MILLION*
*NET FISHING TIMES REDUCED BY APPROXIMATELY 10%*
*GS SPORT FISHING LIMITS: 2 COHO PER DAY, 50 CM SIZE, 6 COHO PER SEASON*

| | WCVI TROLL | GS TROLL | NET | GS SPORT | COMMENTS |
|---|---|---|---|---|---|
| HARVEST RATE | -7% | -93% | -10% | -2% | SOME FOREGONE COMMERCIAL CATCH (SOCKEYE,PINK,CHUM,& |
| COHO CATCH | -8% | -100% | +2% | -9% | U.S. ORIGIN COHO) |

***RESULTS:***

*ESCAPEMENT INCREASES BY 37%*
*EXPLOITATION RATE DECREASES BY 9 PERCENTAGE POINTS*

## *COMMERCIAL REDUCTION LESS THAN SPORT REDUCTION*

### *OPTION 3*

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***3 MANAGEMENT MEASURES:***

*ALL COMMERCIAL FISHERIES REDUCED EQUALLY*
*WEST COAST VANCOUVER ISLAND (WCVI) TROLL CEILING: 1.7 MILLION*
*STRAIT OF GEORGIA (GS) TROLL CEILING: 165,000*
*NET FISHING TIME REDUCED BY APPROXIMATELY 5%*
*STRAIT OF GEORGIA (GS) SPORT FISHING LIMITS: 1 COHO PER DAY, 50 CM MINIMUM SIZE, 5 COHO PER SEASON*

| | WCVI TROLL | GS TROLL | NET | GS SPORT | COMMENTS |
|---|---|---|---|---|---|
| HARVEST RATE | -7% | -4% | -5% | -28% | FOREGONE CATCH REDUCED |
| COHO CATCH | -8% | -8% | +10% | -36% | |

***RESULTS:***

*ESCAPEMENT INCREASES BY 49%*
*EXPLOITATION RATE DECREASES BY 11 PERCENTAGE POINTS*

## 5.0 EVALUATION

Evaluation consists of three stages:

1) evaluation of management options;
2) stock and fishery assessments; and
3) evaluation of the target exploitation rate.

The consultative planning process is critical to the evaluation phase because it helps to establish and later reassess many of the criteria against which the coho rebuilding program is evaluated.

## 5.1 EVALUATION OF MANAGEMENT OPTIONS

Options for rebuilding Strait of Georgia wild coho stocks differ in their likelihood of achieving the needed 10 percentage point reduction in the coho exploitation rate and in their effect on resource allocation. This section explains how the Department proposes to use fishery management models to rank the options according to the following indicators:

- effectiveness in reducing the exploitation rate;
- confidence in the underlying assumptions; and
- effect on the distribution of costs and benefits between user groups.

### EFFECTIVENESS

The effectiveness indicator will measure the effect, in percentage points, of a management option on the exploitation rate. Each option will require specific changes in the Department's management activities (enhancement, habitat and harvest rate management). The challenge will be to predict, using computer models, how such changes will affect harvesting rates and, consequently, fish populations.

### CONFIDENCE

In predicting the effects and enforceability of each option, many assumptions must be made, but some, the key assumptions, will have a much more significant effect on the outcome than others. The reliability of these key assumptions will determine the level of confidence in the predictions. The Department will, therefore, use computer models to test the degree to which changes in the assumptions affect the predictions of the model. Confidence in the accuracy or reliability of the key assumptions will then be rated as high, medium, or low. For example, one option might involve shortening the length of the commercial fishery. To predict the effect of this option, assumptions about harvesting effort and catch per unit effort would have to be made. Since the Department has extensive historical data upon which to base such assumptions, the confidence rating

would be relatively high. Another option might involve spot closures for the sport fishery. In this case, a key assumption might be made about coho migration patterns in particular areas. Confidence in this assumption would be rated as low, since the Department has no data on migration patterns through small areas.

Options will also be rated as low, medium or high in terms of their enforceability. Options requiring harvesters to take actions that cannot be monitored by the Department are likely to be less effective than those regulations that can be easily enforced. For example, closures are easier to enforce than seasonal bag limits.

DISTRIBUTION

Conservation actions will redistribute the catch of coho and other salmon species between and within the native, commercial, and sport sectors. The Department's evaluation will, therefore, assess how each option distributes costs and benefits.

1) Distribution of Costs

   The government will incur financial costs and user groups will face costs in terms of foregone catch of coho and other salmon species when the management measures are implemented. These costs will be quantified by sector. Any significant redistribution of catch within a sector will be evaluated.

2) Distribution of Benefits

   As a result of reduced exploitation rates, stocks will rebuild and future catches of coho will be larger. Increases in future commercial, sport, and native catches will be quantified.

## 5.2 STOCK AND FISHERY ASSESSMENTS

As part of the annual monitoring process, stock status and fishery performance will be evaluated using a variety of indicators, most of which have been used in the current assessment. Adjustments to the rebuilding program will not be made for at least one cycle (three years) because of the high degree of inter-annual variability that is likely to affect any group of management actions. Similarly, as stocks rebuild and new enhancement production comes on line, the effectiveness of management actions may change. Adjustments to the initial management actions may be required at that time.

Key stock exploitation rates will be tracked to monitor over-all fishery management performance. Exploitation rates will continue to be tracked for the hatchery stocks used in the current stock assessment analysis: Big Qualicum River, Quinsam River, Lower Fraser River (Chilliwack, Chehalis and Inch) and the Eagle River in the Thompson

River system. Data for other hatcheries will be evaluated to determine their utility as exploitation rate indicators, as will the data for a number of wild stocks. Black Creek (on Vancouver Island) and the Salmon River (lower Fraser) are the two leading wild stock candidates at this time. Investigation into potential bias (misinterpretation of data) in coded wire tag application and recovery will continue.

Escapement data for index streams will continue to be collected to evaluate the status of spawning escapement by Statistical Area. Improvements to data collection methods and, therefore, the reliability of escapement estimates will be made where appropriate and practical.

Catch in all fisheries and hatchery contributions will continue to be monitored to evaluate the level of wild stock production. Work on achieving a more precise estimation of the U.S. origin catch in Canadian fisheries is on-going within the Pacific Salmon Commission.

The catch distribution of Strait of Georgia coho will continue to be monitored using coded wire tag recovery information. Fishery harvest rates will be estimated using these data in conjunction with the exploitation rate analysis.

Freshwater habitat utilization by rearing coho fry has not been routinely assessed. There has been some work of this type done by enhancement and research personnel, but none on an extensive and consistent basis. Nevertheless, a comprehensive assessment of coho stock status would benefit from the inclusion of this kind of information. Research programs have been proposed to determine the most cost effective way of determining the status of freshwater habitat utilization.

### 5.3 EVALUATION OF THE TARGET EXPLOITATION RATE

This longer term evaluation will be conducted in two ways. The first involves detailed studies of the productivity of specific coho salmon stocks. Factors controlling production, including the level of spawning escapement required to maximize catch, will be investigated. In the second approach, spawner and recruit data collected over the long term are analyzed to determine the spawning level that would maximize catch. Recruits are fish which survive the rearing stage to become available to fisheries. These data will be obtained from a small number of intensively monitored streams. Any discrepancies in the ideal spawning escapements determined using these two methods will be reconciled as part of the evaluation process.

## 6.0 WORKSHOP 2

The following section outlines the objectives for the second workshop. The format of the workshop is described and suggestions are provided to prepare the advisors for the meetings.

### 6.1 OBJECTIVES

1) To review and discuss the recommendations for habitat and enhancement

2) To discuss the proposed procedure for evaluating the merits of specific options

3) To review the responses to the questions raised at the first workshop

4) To discuss management measures which reduce harvest rates in the fisheries and to receive input on the impacts of the measures on the different sectors

5) To discuss the components of the final report to PARC and the Minister

### 6.2 FORMAT

For each sector, the second workshop will be two days long. It is proposed to review the Interim Report and its various sections on the first day. The second day would then be spent discussing the options for reducing harvest rates and, finally, outlining the content of the Final Report.

The area of management measures requires additional attention. In workshop discussions, neither the sport nor the commercial sector was prepared to suggest any specific measures to reduce the harvest rate in its fishery. Discussion has been stalled because both sectors believe that the other sector should be reduced. As a consequence the Department has analyzed a number of different options, which are outlined in Section 4.0. In the second workshop, the Department will discuss the implications of the different options and receive input from the advisors on the merits and potential impacts of the specific options.

### 6.3 PREPARATION

To prepare for the second workshop, it is suggested that the advisors consider the points listed below.

1) The advisors should review the recommendations for addressing the habitat and enhancement components of the Initiative. Do the advisors support these approaches? If not, what other suggestions would they make to address these concerns?

2) This Interim Report outlines several measures for reducing harvest rates. Are there other measures that should be considered? If so what are they? As well, the Department would like to record advisors' views on the possible impacts of specific measures on the different sectors; therefore, consideration should be given to providing advice in this area.

3) The Department would like advisor's opinions on the possible approach for evaluating the merits of the different options presented in this report. Are there other approaches for evaluating the options and, if so, what are they?

# APPENDIX

## TABLE 1: AVERAGE PERCENT CHANGE IN COHO HARVEST RATE AND CATCH UNDER THREE HARVEST RATE REDUCTION SCENARIOS (SEE PAGES 60-62 FOR DESCRIPTION OF OPTIONS)

| | 1986 TO 1989 AVERAGE CHANGE | | | | | | ESCAPEMENT CHANGE | EXPLOITATION RATE REDUCTION | OVEREXPLOITED STOCK GROUPS/ YEARS OVEREXPLOITED | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | WCVI TROLL | GS TROLL | JDF NET | JST NET | TERMINAL NET | GS SPORT | | | | |
| REDUCTION OPTION 1: COMMERCIAL = SPORT | | | | | | | | | | 1A: Sockeye, pink & chum catch in net fisheries declines, on average, by 100K, 305K & 85K, respectively. GS sport & troll forego 35K & WCVI foregoes 225K U.S. origin coho. 1B: GS sport and troll forego 65K U.S. origin coho. |
| 1A HARVEST RATE | -14% | -15% | -15% | -15% | -15% | -14% | 31% | 10% | LWFR/2 | |
| CATCH | -17% | -16% | -9% | -10% | 14% | -21% | | | | |
| 1B HARVEST RATE | 0% | -93% | 0% | 0% | 0% | -9% | 42% | 10% | LWFR/2 | |
| CATCH | 0% | -100% | 0% | 0% | 35% | -17% | | | | |
| REDUCTION OPTION 2: COMMERCIAL > SPORT | | | | | | | | | | 2A: Foregone sockeye, pink & chum catch in net fisheries greater than in 1A. GS sport & troll forego 15K & WCVI troll foregoes 300K U.S. origin coho. 2B: Foregone sockeye, pink & chum catch in net fisheries less than in 1A. GS sport & troll forego 50K & WCVI troll foregoes 75K U.S. origin coho. |
| 2A HARVEST RATE | -20% | -30% | -20% | -20% | -20% | -2% | 32% | 8% | LWFR/3 SEVI/1 | |
| CATCH | -26% | -30% | -11% | -14% | 1% | -6% | | | | |
| 2B HARVEST RATE | -7% | -93% | -10% | -10% | -10% | -2% | 37% | 9% | LWFR/3 | |
| CATCH | -8% | -100% | -6% | -7% | 20% | -9% | | | | |
| REDUCTION OPTION 3: SPORT > COMMERCIAL | | | | | | | | | | 3: Foregone sockeye, pink & chum catch in net fisheries considerably less than in 1A. GS sport & troll forego 55K & WCVI troll foregoes 75K U.S. origin coho. |
| HARVEST RATE | -7% | -4% | -5% | -5% | -5% | -28% | 40% | 11% | LWFR/2 | |
| CATCH | -8% | -8% | -1% | -3% | 33% | -36% | | | | |

WCVI TR = WEST COAST VANCOUVER ISLAND TROLL
GS TR = STRAIT OF GEORGIA TROLL
JDF NET = JUAN DE FUCA NET
JST NET = JOHNSTONE STRAIT NET
TERM NET = TERMINAL NET
GS SPORT = STRAIT OF GEORGIA SPORT

LWFR = LOWER FRASER RIVER
SEVI = SOUTHEAST VANCOUVER ISLAND

TABLE 2: PERCENT CHANGE IN HARVEST RATE UNDER THREE HARVEST RATE REDUCTION SCENARIOS (SEE PAG 60-62 FOR DESCRIPTION OF OPTIONS)

| | 1986 TO 1989 AVERAGE CHANGE | | | | | | ESCAPEMENT CHANGE | EXPLOITATION RATE REDUCTION | OVEREXPLOITED STOCK GROUPS/ YEARS OVEREXPLOITED | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | WCVI TROLL | GS TROLL | JDF NET | JST NET | TERMINAL NET | GS SPORT | | | | |
| REDUCTION OPTION 1: COMMERCIAL = SPORT | | | | | | | | | | |
| 1A Base Year | | | | | | | | | | |
| 1986 | -6% | -21% | -15% | -15% | -15% | -10% | 27% | 7% | LWFR | 1A: Sockeye, pink & chum catcl |
| 1987 | -20% | -19% | -15% | -15% | -15% | -6% | 28% | 7% | LWFR | net fisheries declines, on average |
| 1988 | -15% | -36% | -15% | -15% | -15% | -30% | 89% | 17% | | by 100K, 305K & 85K, respective |
| 1989 | -14% | 17% | -15% | -15% | -15% | -14% | 22% | 7% | | GS sport & troll forego 35K & V |
| AVERAGE | -14% | -15% | -15% | -15% | -15% | -15% | 41% | 10% | | foregoes 225K U.S. origin coho. |
| 1B Base Year | | | | | | | | | | |
| 1986 | 0% | -92% | 0% | 0% | 0% | -4% | 33% | 8% | LWFR | 1B: GS sport and troll forego 65 |
| 1987 | 0% | -94% | 0% | 0% | 0% | 0% | 38% | 9% | LWFR | U.S. origin coho. |
| 1988 | 0% | -94% | 0% | 0% | 0% | -22% | 75% | 14% | | |
| 1989 | 0% | -91% | 0% | 0% | 0% | -11% | 23% | 8% | | |
| AVERAGE | 0% | -93% | 0% | 0% | 0% | -9% | 42% | 10% | | |
| REDUCTION OPTION 2: COMMERCIAL > SPORT | | | | | | | | | | |
| 2A Base Year | | | | | | | | | | |
| 1986 | -14% | -34% | -20% | -20% | -20% | -1% | 30% | 8% | LWFR | 2A: Foregone sockeye, pink & c |
| 1987 | -28% | -42% | -20% | -20% | -20% | 4% | 32% | 8% | LWFR | catch in net fisheries greater thar |
| 1988 | -22% | -50% | -20% | -20% | -20% | -5% | 48% | 9% | SEVL LWFR | 1A: GS sport & troll forego 15K |
| 1989 | -18% | 7% | -20% | -20% | -20% | -6% | 19% | 6% | | WCVI troll foregoes 300K U.S. c |
| AVERAGE | -20% | -30% | -20% | -20% | -20% | -2% | 32% | 8% | | coho. |
| 2B Base Year | | | | | | | | | | |
| 1986 | -3% | -92% | -10% | -10% | -10% | 1% | 34% | 9% | LWFR | 2B: Foregone sockeye, pink & cl |
| 1987 | -14% | -95% | -10% | -10% | -10% | 13% | 30% | 8% | LWFR | catch in net fisheries less than in |
| 1988 | -7% | -94% | -10% | -10% | -10% | -14% | 68% | 13% | LWFR | GS sport & troll forego 50K & W |
| 1989 | -5% | -91% | -10% | -10% | -10% | -7% | 15% | 8% | | troll foregoes 75K U.S. origin coh |
| AVERAGE | -7% | -93% | -10% | -10% | -10% | -2% | 37% | 9% | | |
| REDUCTION OPTION 3: SPORT > COMMERCIAL | | | | | | | | | | |
| 3 Base Year | | | | | | | | | | |
| 1986 | -3% | 2% | -5% | -5% | -5% | -28% | 32% | 8% | LWFR | 3: Foregone sockeye, pink & chu |
| 1987 | -14% | -15% | -5% | -5% | -5% | -23% | 41% | 10% | LWFR | catch in net fisheries considerably |
| 1988 | -7% | -37% | -5% | -5% | -5% | -39% | 96% | 19% | | less than in 1A: GS sport & troll |
| 1989 | -5% | 29% | -5% | -5% | -5% | -28% | 26% | 8% | | forego 55K & WCVI troll forego |
| AVERAGE | -7% | -5% | -5% | -5% | -5% | -29% | 49% | 11% | | 75K U.S. origin coho. |

ABLE 3: PERCENT CHANGE IN COHO CATCH UNDER THREE HARVEST RATE REDUCTION SCENARIOS (SEE PAGES 60-62 FOR DESCRIPTION OF OPTIONS)

| | 1986 TO 1989 AVERAGE CHANGE | | | | | | ESCAPEMENT CHANGE | EXPLOITATION RATE REDUCTION | OVEREXPLOITED STOCK GROUPS/ YEARS OVEREXPLOITED | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|
| | WCVI TROLL | GS TROLL | JDF NET | JST NET | TERMINAL NET | GS SPORT | | | | |
| EDUCTION OPTION 1: OMMERCIAL = SPORT | | | | | | | | | | |
| A: Base Year | | | | | | | | | | |
| 1986 | -12% | -25% | -12% | -9% | 3% | -14% | 27% | 7% | LWFR | 1A: Sockeye, pink & chum catch in net fisheries declines, on average, by 100K, 305K & 85K, respectively. GS sport & troll forego 35K & WCVI foregoes 225K U.S. origin coho |
| 1987 | -23% | -22% | -5% | -8% | 3% | -11% | 28% | 7% | LWFR | |
| 1988 | -16% | -43% | -5% | -11% | 48% | -39% | 89% | 17% | | |
| 1989 | -19% | 15% | -13% | -12% | 3% | -18% | 22% | 7% | | |
| AVERAGE | -17% | -19% | -9% | -10% | 14% | -21% | 41% | 10% | | |
| B: Base Year | | | | | | | | | | |
| 1986 | 0% | -100% | 0% | 0% | 28% | -12% | 33% | 8% | LWFR | 1B: GS sport and troll forego 65K U.S. origin coho. |
| 1987 | 0% | -100% | 0% | 0% | 27% | -9% | 38% | 9% | LWFR | |
| 1988 | 0% | -100% | 0% | 0% | 66% | -32% | 75% | 14% | | |
| 1989 | 0% | -100% | 0% | 0% | 19% | -17% | 23% | 8% | | |
| AVERAGE | 0% | -100% | 0% | 0% | 35% | -17% | 42% | 10% | | |
| EDUCTION OPTION 2: OMMERCIAL > SPORT | | | | | | | | | | |
| 2A: Base Year | | | | | | | | | | |
| 1986 | -22% | -37% | -13% | -12% | -3% | -5% | 27% | 7% | LWFR | 2A: Foregone sockeye, pink & chum catch in net fisheries greater than in 1A. GS sport & troll forego 15K & WCVI troll foregoes 300K U.S. origin coho. |
| 1987 | -32% | -41% | -7% | -11% | 1% | 0% | 32% | 8% | LWFR | |
| 1988 | -24% | -51% | -6% | -15% | 11% | -11% | 48% | 9% | SEVL LWFR | |
| 1989 | -24% | -7% | -17% | -16% | -5% | -8% | 19% | 6% | | |
| AVERAGE | -26% | -31% | -11% | -14% | 1% | -6% | 32% | 8% | | |
| 2B: Base Year | | | | | | | | | | |
| 1986 | -5% | -100% | -9% | -6% | 15% | -7% | 34% | 9% | LWFR | 2B: Foregone sockeye, pink & chum catch in net fisheries less than in 1A. GS sport & troll forego 50K & WCVI troll foregoes 75K U.S. origin coho. |
| 1987 | -15% | -100% | -3% | -5% | 13% | 6% | 30% | 8% | LWFR | |
| 1988 | -8% | -100% | -5% | -8% | 42% | -24% | 68% | 13% | LWFR | |
| 1989 | -6% | -100% | -9% | -8% | 9% | -12% | 15% | 8% | | |
| AVERAGE | -8% | -100% | -6% | -7% | 20% | -9% | 37% | 9% | | |
| REDUCTION OPTION 3: SPORT > COMMERCIAL | | | | | | | | | | |
| 3: Base Year | | | | | | | | | | |
| 1986 | -5% | -3% | -4% | -3% | 20% | -34% | 32% | 8% | LWFR | 3: Foregone sockeye, pink & chum catch in net fisheries considerably less than in 1A. GS sport & troll forego 55K & WCVI troll foregoes 775K U.S. origin coho. |
| 1987 | -15% | -10% | 2% | -1% | 24% | -30% | 41% | 10% | LWFR | |
| 1988 | -8% | -42% | 0% | -3% | 74% | -48% | 96% | 19% | | |
| 1989 | -6% | 26% | -4% | -4% | 16% | -33% | 26% | 8% | | |
| AVERAGE | -8% | -7% | -1% | -3% | 33% | -36% | 49% | 11% | | |